The Welding Engineer

Reg. U. S. Pat. Office

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TORCHWELD

"Non-flash construction"

"Produce clean cuts"

"Will stand all kinds of abuse and *Keep Going*"

The "boys" who use them know.

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The Welding Engineer
P. F. Willis

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See also "Torches."

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International Oxygen Co.
F. H. Wheeler Mfg. Co.

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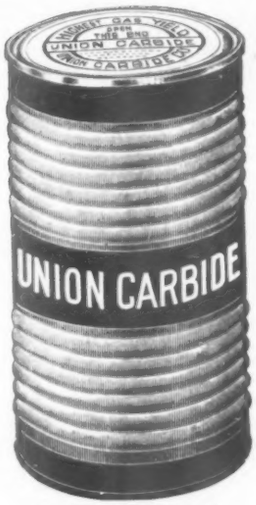

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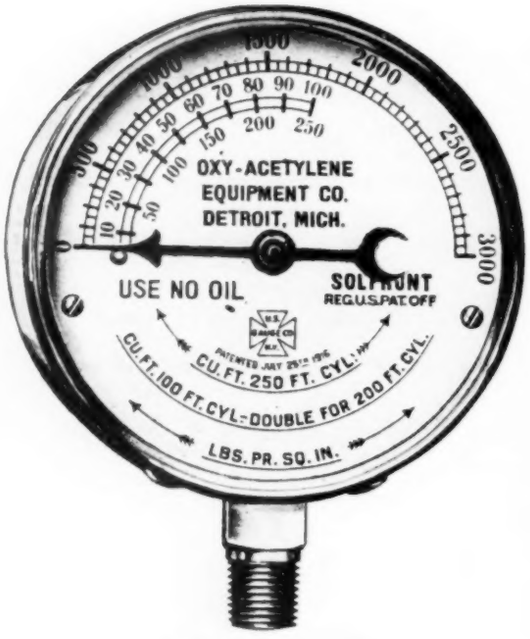

Patented July, 1916

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for

WELDING and CUTTING APPARATUS

United States Gauge Co.

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Here's the Reason Why:

"FEDERAL" Regulators are made of the very best materials by expert mechanics for expert welders who know the value of and appreciate absolutely dependable Regulators.

They are passed by the National Board of Underwriters and their safety features make accidents to operators practically impossible.

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Universal All-Steel Welding Truck

A time-saver and convenience which no progressive welding shop can afford to be without. Made in two sizes; to carry two 100 ft. drums, and to carry two 200 ft. drums.

Truck is equipped with torch hooks on which the torch can be conveniently placed when not in use, and a ten hole tip rack. The welding rod supply box is made to carry eight pounds of welding rods. The supply case, spaced off into compartments, will carry two one-pound cans of flux, cutting tips, adaptors, goggles and wrenches.

The truck has a hand wheel drum tightening device, strongly constructed, and so made that the drums are held tightly, eliminating any shaking when the truck is in motion.

The entire truck is constructed of heavy angle iron, and has a 10 gauge steel platform. It is so constructed that when fully loaded it will balance easily, facilitating rapid transportation. WRITE FOR PRICES TODAY

UNIVERSAL OXYGEN COMPANY : Sheboygan, Wisconsin

Milwaukee Branch, 554-556 E. Water St.

High Silicon Cast Iron Welding Rods

Atlas Quality

Also rods, wires and fluxes for welding all metals. Quality guaranteed.

Prices Cheerfully Quoted.

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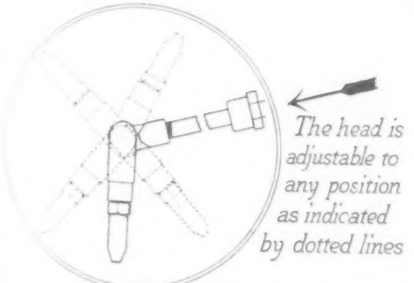
Tobin's Adjustable Head

Operates from any position. No loss of time or gases. The nozzle may be moved into any desired position without twisting or rotating the handle or hose.



The head is adjustable to any position as indicated by dotted lines

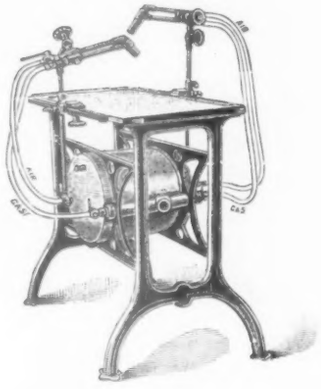
THE TOBIN ADJUSTABLE HEAD

may be attached to any standard welding torch. It is now in successful operation on the Pacific Coast, particularly on Burdett Torches. A constant and uniform flow of gas is assured—no change in your regular torch—simply more flexibility in manipulation. This torch was used on cabinet work on U. S. Destroyers in ship yards, the most inaccessible work being handled with ease. The Tobin Head is equally efficient on heavy work.

When writing for information send sketch of your torch, showing size of threads.

Write for prices and particulars.

R. J. Tobin P. O. Box 905 RICHMOND, CALIF.

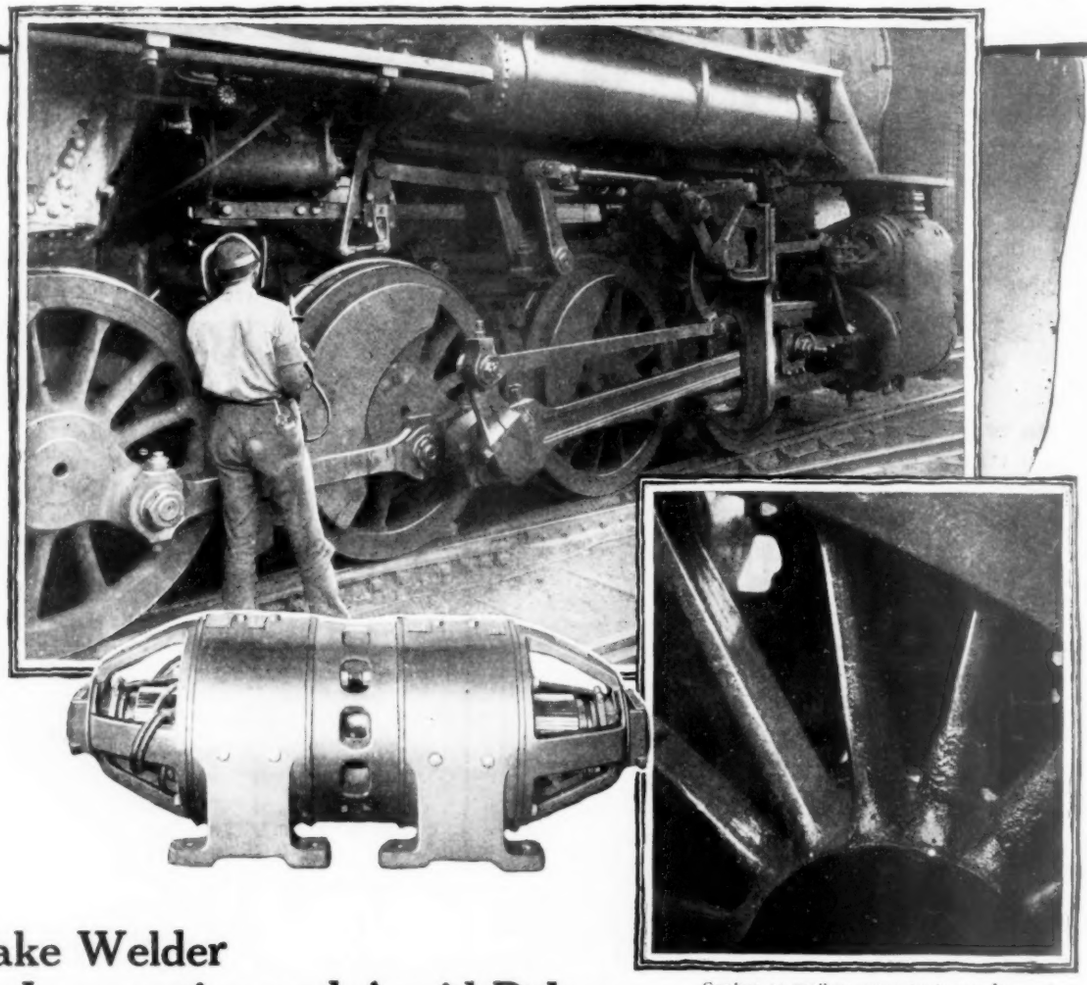


Clean and Quick Method of Brazing

B. D. M. Co.'s No. 101 Gas Brazing Stand for tool rooms or manufacturing purposes, has two powerful gas blowpipes which are adjustable in any direction. The substantial iron frame carries also an air drum and necessary connections as illustrated. Equally effective for a small piece of soldering, or for a heavy job of brazing requiring both blowpipes and a built-up fire-brick backing. Price $40.00. Catalog "B.X.," to be had for the asking, tells all about it.

Buffalo Dental Mfg. Co.
Buffalo, N. Y.

The time has come when the electrical and mechanical men of steam railroads should aid in the conservation of iron and steel by the electric arc-welding process.—*A. R. E. E. Committee Report, October, 1918*



Spokes as well as worn parts can be readily welded

Take Welder to Locomotive and Avoid Delays

If repair shop or roundhouse is crowded you can spot locomotive in yards and carry a G-E portable welding outfit out to it.

A great many repair jobs, such as slid flat spots on drivers, can be repaired by arc welding in as many hours as days are usually required where old repair methods are used.

The G-E constant energy arc-welding sets used are highly efficient in operation and assure a steady flow of metal into the weld.

One small roundhouse in twenty-four days saved $378.68, difference between scrap value and new price, by welding small engine parts, and made it possible to almost immediately return the engines to service.

We will be pleased to instruct your welders in our school while your welding sets are being built, and thus help assure you maximum benefits from arc welding.

General Electric Company

General Office Schenectady, N.Y.

Overhead Leak Eats Up Profit

If you ask the owner of the average welding shop if he is making a profit, he will answer yes. If you ask him if his shop shows any overhead leaks, he will say no.

With the Present Methods of Preheating There Is Bound to Be Overhead Leakage

In the first place where charcoal is used, fires must be built, and built or confined with fire brick. Fire brick costs money, and the time it takes to build and start a fire costs money. Lighting a fire with kerosene or gasoline costs money, and very often the helper or welder is tempted to use his welding torch to start the fire. Oxygen and acetylene cost money. On opening up the shop in the morning, yesterday's fires must be cleaned up. Time wasted. And time costs money. Many jobs crack and have to be rewelded because of imperfect preheating. Another waste of time and waste of welding metal, and gases.

These are only a few of the more flagrant overhead leaks that occur in every shop.

The Wiederwax Preheater Cuts Out This Waste

To begin with, it does away with charcoal, thus eliminating fire building, fire brick, and wasted time in cleaning up old fires. It saves labor. It burns gas, at a cost of about one quarter that of charcoal. It preheats in half the time—and in many cases in less than half the time—it takes with charcoal. It gives an even, soft, radiant heat which is controllable at all times, and is especially adapted to castings with large flat surfaces. It removes the danger of uneven expansion and contraction, and its cooling oven reduces the heat of a piece quickly and safely without danger of fracture or warping. It is efficient, thorough, safe and reliable.

That Dollar Which Evaporates in Overhead Might Just as Well Be in Your Pocket. - Write Today for Our Free Booklet!

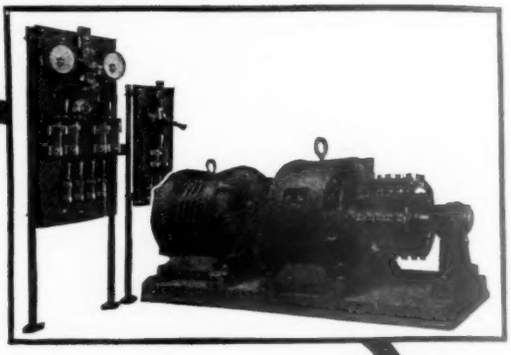
The Geist Manufacturing Company

2001 Atlantic Avenue - - Atlantic City, N. J.

Your Welding Equipment Must Supply

"PEP" AND STABILITY

To The Welding Arc



The three prime requisites of Electric Arc Welding Equipments are—

1. Sufficient potential capacity to sustain the arc when lengthened, for you have to overcome irregularities in the material being welded, which causes variations in the resistance of the circuit.
2. In starting the arc your current should not shoot up too high, but should be above the normal welding current in order to give the necessary heat at the start.
3. **Constant heat** at the arc. This requires variable voltage at the arc to maintain constant current, **as the heat of the arc depends on the current flowing.** The reason that variable voltage is required to maintain constant current is due to variation in the resistance of the arc path or circuit due to the following (a) foreign matter such as scale, rust, etc., in the path of the arc, (b) variations in the length of the arc caused by the molten metal traveling from the electrode to the weld, (c) unsteadiness of the operator's hand and (d) unevenness of the surface over which the welding arc is directed.

Westinghouse Electric Arc Welding Equipments meet these requirements.
Built in sizes from 150 ampere to 1,000 ampere capacity.

1. Single operator equipment—Stationary type.
2. Single operator equipment—Portable type.
3. Multiple operator equipment.

Built for all commercial circuits; either alternating or direct current.

Westinghouse Electric & Mfg. Co.
East Pittsburgh, Pa.

W WESTINGHOUSE ELECTRIC

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We Can Save You Money

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GAS AND OXYGEN

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WELD-A-CAST Trade Mark FLUXES

"Weld-a-cast" is a scientific combination of chemicals, that causes the metal to melt rapidly, shortening the operation, thus economizing in time, gas and oxygen.

"Weld-a-cast" adheres readily to the hot welding rod which picks up just enough and none is wasted; it does not blow away but melts at once; it eliminates blow holes and leaves the metal soft.

Write For Free Samples

CORTLAND WELDING COMPOUND CO.
CORTLAND, N. Y.

Welding Pincers

Use up the short pieces of Welding Metal

This pincer enables the welder to use up his strips of metal almost to the end, all the time keeping his hand a good distance from the heat.

The handle is always cool, no matter how short is the piece of welding metal.

The time saved in welding the strips together quickly pays for the pincers.

Pressing the spring handle releases the jaws to pick up the metal. Length of pincers, 19 inches. Holds rods of 3-16-inch to ½-inch diameter.

Price $1.00

One sent to the address of any welding shop for 30 days' trial, on receipt of $1.00. If not satisfied money will be refunded on return of pincers.

Jobbers and Agents, write

C. SORENSEN

18 E. 16th St. CHICAGO

Hold on! What were you doing just then? Storing away that interesting bit of welding experience, or a photograph, perhaps? Don't do it? Give it to us. We want to show it to 4,099 other readers of The Welding Engineer (you're the forty-one hundredth). If there are objectionable features to it, just leave it to the Editor (he studied surgery), cutting off and adding to is his hobby.

Another thing, when you work out a successful solution to a welding problem write us about it. Grammar and composition don't count—it's ideas we want. If a sketch would illustrate your job in good shape, just make a rough pencil sketch; our draughtsman will do the rest.

If the welding industry is to grow, you welders must pass along your experiences. We pay for them.

THE WELDING ENGINEER

608 S. DEARBORN ST., CHICAGO

Swift Oxygen

For Welding and Cutting

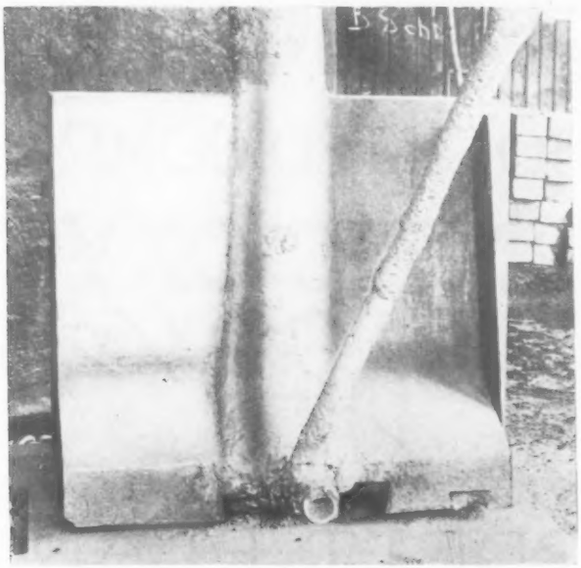
Unsurpassed for Quality

Pure Oxygen Electrolytically Made under the direct supervision of our Chemical Laboratory. It is carefully controlled by chemical analysis, thus insuring the highest obtainable purity.

We carry a large stock on hand—so can fill orders immediately

Swift & Company

Oxygen Department **Union Stock Yards, Chicago, Ill.**



Thermit weld made on large drop hammer, showing gate and riser before machining.

Here Is What A Large Drop Forging Company In Canton, O., Has Accomplished With Thermit Welding

Judging from what Thermit had done in the way of repairing heavy sections in other large manufacturing plants, this drop forging company ordered a Thermit outfit.

Since the purchase of the Thermit outfit, the following repairs have been made:

1 shear frame housing
1 crankshaft of an Ajax upsetting machine
1 6-in. crankshaft
1 5-in. three-throw crankshaft
Steam hammer rams
Steam hammer anvils

The Thermit welding of these parts saved thousands of dollars in time and money by returning them to service quickly.

Thermit is the only welding process which has and can successfully repair heavy sections. The fact that over one million and a half pounds of Thermit were used by the railroad companies and steel mills during 1918 is ample proof of its efficiency and economy over all other methods for welding heavy machine parts.

Our pamphlet No. 1779 describes the operation of the process and illustrates the class of repair work for which it is best adapted.

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ELECTROLYTIC OXYGEN and HYDROGEN - 99 1/2 % Pure

Service from the following BURDETT PLANTS

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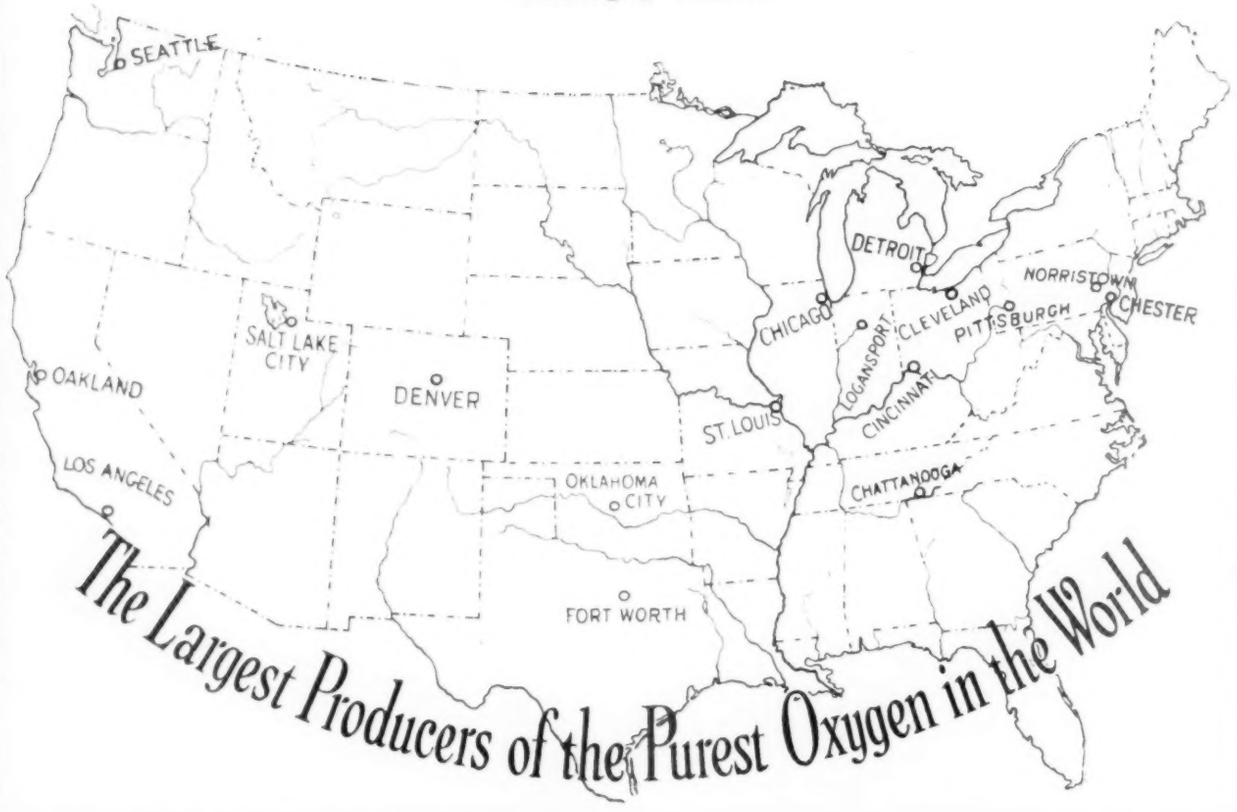


The Largest Producers of the Purest Oxygen in the World

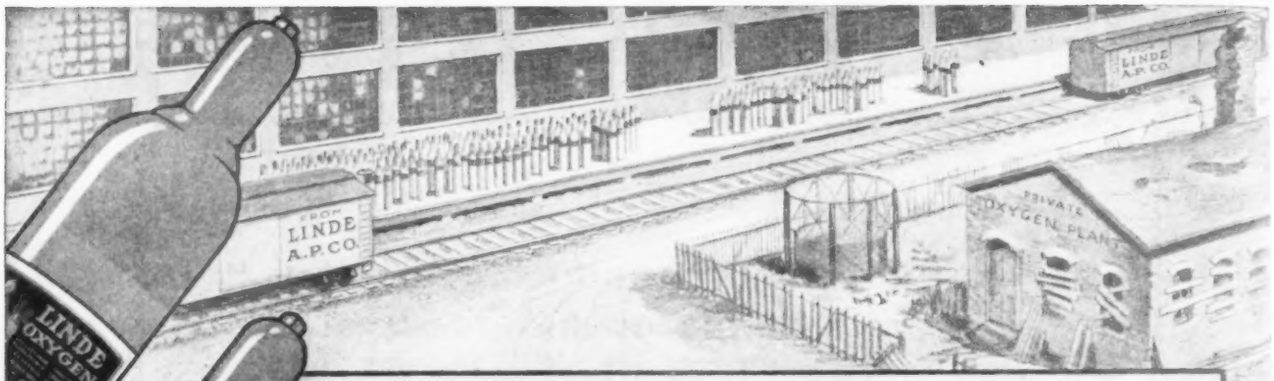
During the hurry and excitement of war times, none of us investigated the merits of competing machines as closely as we should. We were influenced largely by promises of prompt delivery.

In a short while we will again be on a peace basis. Competition will then compel us to buy THE MOST EFFICIENT. The wise man will employ the present transitional period in investigation. Examine a Willis Welder. Try one. Willis Welders are Good Welders.

Henderson Willis W. & C. Co.,
2305-15 North 11th Street,
St. Louis, Mo.

ATTENTION! WELDERS!

Do you want to know how to fix scored cylinders quickly and easily without the necessity of re-boring and so the old pistons can be used? If so, send us self addressed stamped envelope together with the name and address of a firm using oxy-acetylene welding or cutting and the make of apparatus in use and we will send full instructions without cost.



Demonstrating the Advantages of Linde 65-Station Service Over the Private Plant

LINDE success in meeting the tests imposed by abnormal conditions has exposed the weakness of private plant service.

These private plants, many of which have already fallen by the wayside, were installed on the theory that they would prove economical and dependable.

In actual practice the fallacy of the theory has been conclusively shown by balance sheet comparisons—comparisons of the cost of operation and the actual service rendered by these two competing sources of supply.

Among the factors contributing to the failure of the private plant in all these cases are the following:

1. Unlooked for increases in Oxygen consumption—far beyond the capacity of single plant service;
2. Unlooked for operating trouble—involving temporary failure of supply and expensive repairs;
3. Unlooked for operating expenses—upsetting manufacturing estimates;
4. Unlooked for deterioration—upsetting depreciation calculations;
5. And last, but not least, the extension of Linde Service through new factories and warehouses to provide a nearer and more convenient source of supply for each district.

These are but a few of the factors that have brought about the discontinuance of many private plants, by concerns who have written off their investments to place their dependence in Linde Oxygen exclusively.

This service the Linde Company alone can render—service made possible through the Company's chain of 65 distributing stations backed by its enormous manufacturing facilities.

In maintaining this service to these users, the Linde Company often finds it necessary to "shift the load" from one of its distributing stations to another—to meet suddenly increased and widely fluctuating demands.

The Linde Air Products Company
30 East 42d Street New York
"Largest Producer of Oxygen in the World"

819

HARD SPOTS *in* CAST IRON WELDS

By S. W. Miller*

MUCH has been written in *The Welding Engineer* and other papers regarding the so-called "hard spots" in cast iron welds, and their cause has been many times explained correctly. The matter bobs up serenely, however, from time to time, and it would seem advisable to go into more detail in regard to them than has hitherto been done, as far as the author knows.

To do this will require considerable explanation of details, and some patience and study on the part of the average welder, who, by force of circumstances and through no fault of his own, is not acquainted with some of the elementary facts in regard to the structure of iron and steel, and, therefore, doing the best he knows how, stumbles along, sometimes having no hard spots and again being bothered with them to his disgust and sometimes dismay.

This article is written in the belief that, if the real cause of hard spots is thoroughly understood, any welder, by using a little common sense, can at all times avoid them, or if, as may occasionally be the case, this is not possible, he may know what to expect and notify his customer accordingly, so there will be no misunderstanding, or hard feelings.

To begin with, we all know that a piece of tool steel, such as a cold chisel, may have the cutting edge hardened by heating it red hot and plunging in water, also that it may be tempered or made somewhat softer and less brittle, by warming up to less than a red heat, and allowing it to cool, either in air or by again quenching it. We also know that a piece of wrought iron cannot be so hardened. Again, we have become aware by experience that a chisel that has been hardened, may be again softened by heating to a red heat and cooling slowly, and that the slower the cooling, the softer it will be when cold. So that:

First: It is evident that there is some relation between the rate of cooling and the hardness of the steel, because this is the only difference in the treatment, and we deduce that *rapid cooling* is the cause of the steel hardening, and that *slow cooling* makes it soft.

Second: As wrought iron cannot be hardened by quenching from a red heat, we deduce that there must be some difference between the two metals, and that tool steel must contain something that wrought iron does not, which enables it to be made hard by quenching.

Both of these deductions are correct. In the latter case, the chemist finds that tool steel contains carbon, and that wrought iron does not, and that if enough carbon is added to wrought iron, it becomes tool steel. In the former case, we readily convince ourselves, by repeated trials, that our idea is correct.

Taking a further step, we ask the chemist to analyze a piece of hardened tool steel, and a piece of the same steel unhardened. He advises us that each contains the same amount of carbon and other elements, and we wonder how it can be true. Certainly the two pieces of steel have widely different physical properties; the former is very strong, very hard and very brittle; while the latter can be easily filed or machined, is quite ductile, and not nearly so strong. Thinking the matter over, the only thing we can see is that some physical change must occur on account of the quenching, as there is no other supposition that will account for the facts. It is not the intention of the author to trace the various steps made by the pioneers in this work, but he does desire (and it is necessary to a correct understanding of hard steel) to begin at the bottom and explain the terms and principles that are involved.

The microscope has proven the best means of determining the physical changes occurring in metals due to different heat treatments, and we will make liberal use of its powers of analysis. The following statements will be accepted as true, having been proven by competent investigators and accepted by nearly all metallurgists:

First: Carbon does not exist in steel as carbon, but as a chemical compound, carbide of iron[1], which is dissolved in the iron of the steel at high temperatures, but which will not stay dissolved when the temperature falls below about 1,300 degrees F.

Second: In cold steel the carbide of iron exists under normal conditions mechanically mixed with some of the iron. Both are in the shape of thin plates, arranged alternately, sometimes straight, and sometimes curved. Many times this mechanical mixture takes on the appearance of the whorls on the finger tips.

Third: The iron in steel is called ferrite, to distinguish it from the usual terms "iron" or "steel," which include the whole mass; that is, ferrite is only one of the structural constituents of "iron" or "steel," which are not all ferrite.

Fourth: So that the mechanical mixture of iron and carbide of iron is usually described as alternate plates of cementite and ferrite, and for a short name "pearlite" has been adopted, as under reflected light it has a luster like mother of pearl. These plates are very thin, less than 1/25,000 of an inch.[1]

So far we have to remember, therefore, the three terms, cementite, ferrite and pearlite, surely not a very hard task.

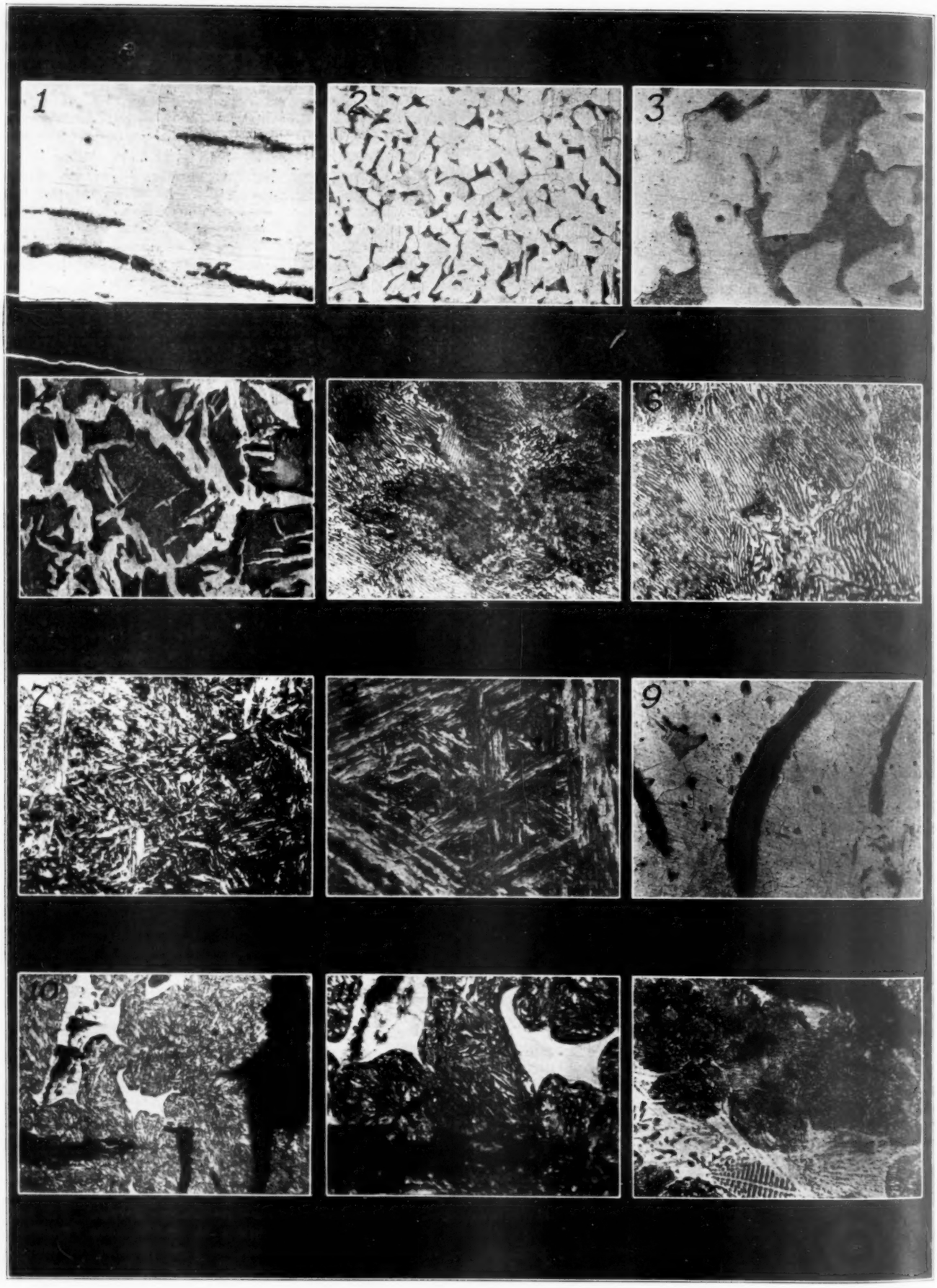
Fifth: The essential difference between steel and cast iron is that cast iron contains more carbon than steel. Commercial steel and cast iron both contain other elements, such as silicon, manganese, sulphur and phosphorus, and their presence or absence affects the quality of the steel or cast iron materially. But carbon exerts the greatest influence, and is, in fact, the element necessary for hardening steel.

Sixth: We may make a series of alloys of any two metals or elements, the amounts of each metal varying, but the sum of the two amounts being constant. For example, we may use 90 per cent copper and 10 per cent tin, or 50 per cent copper and 50 per cent tin, or 10 per cent copper and 90 per cent tin. Some of these will be of no value practically, but they can be made. It is also evident that some one of these alloys will have a lower melting point than any of the others. This alloy is called the "eutectic" alloy of the series, from the Greek words meaning well melting. (There are a few series of alloys in which there are no eutectics, but the above explanation is sufficient for our purpose, and is generally true.)

The structure of a eutectic is usually banded, resembling pearlite. Sometimes it is in the shape of round or elongated globules in the ground mass. The term eutectoid, which means resembling a eutectic, is used to describe a structure resembling in appearance a eutectic, but which is not an alloy of the lowest melting point, as it does not form when the metal solidifies from fusion, but sometimes afterward. Pearlite shows such a structure, and as it is not a eutectic, the term eutectoid is applicable to it. We have now five terms to remember, which are all that are needed for the purpose.

*Proprietor Rochester Welding Works, Rochester, N. Y.

[1](Carbide of iron is a chemical compound just as is calcium carbide, with which every welder is familiar. The chemical formula of iron carbide is Fe_3C, meaning three parts of iron (Fe) and one part of carbon (C) by weight. Calcium carbide is represented by the formula CaC_2, meaning one part of calcium (Ca) and two parts of carbon (C) by weight. The technical name of carbide of iron is cementite. It is the hardest component of steel; it will scratch glass, and is also very brittle. It is brilliant white after etching, and after polishing projects above the rest of the surface. The carbon in the carbide of iron is the same chemically as the material of which an electric light carbon, or the lead in a pencil is made.)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They are: Ferrite, cementite, pearlite, eutectic and eutectoid.

As pure iron is the basis both of steel and cast iron, we will see what it looks like under the microscope and then determine what differences are made by the addition of carbon and other elements.

Photo No. 1 shows fairly pure wrought iron welding wire. The black streaks and specks are slag. It will be noticed that the metal is composed of a large number of different sized grains, the boundaries showing dark and continuous, and the grains almost uniformly bright and clear. The grains are ferrite, practically pure. The boundaries are really shadows thrown by the edges of the grains, the surfaces of which are not all of the same height, owing to the action of the etching acid not being the same on each grain.

Photo No. 2 is of a piece of boiler plate, containing about .18 per cent carbon. The only difference[2] between this and Photo No. 1 is that in the No. 2 there are some dark irregular shaped patches between the corners of the grains. Under high magnification, as in Photo No. 3, the structure of these dark spots shows duplex, consisting of alternate light and dark plates. This duplex structure is pearlite as before explained.

If we examine ordinary machine steel, such as we purchase at an iron store, or a piece of structure steel, such as an I beam, either of which contains, say, .3 per cent carbon, we find steel more of the pearlite. The amount still further increases as the carbon increases, as shown in Photo No. 4, from a piece of shell steel, containing about .45 per cent carbon, and Photo No. 5, from a locomotive tire, containing about .77 per cent carbon. It will be noticed that No. 5 is composed almost entirely of pearlite, there being very little free ferrite, that is, ferrite other than that in the pearlite. It has been found that a pure iron-carbon alloy of about .9 per cent carbon is composed entirely of pearlite and it is, therefore, called eutectoid steel, pearlite being the eutectoid of iron and carbon.[2]

In Photo No. 6, from a piece of tool steel containing about 1.1 per cent carbon, we see a structure that somewhat resembles that of Photo No. 5, but with the difference that there is white material around the grains. Tests prove that this white material is cementite, and it is called free or excess cementite to distinguish it from the cementite in the pearlite, there being more of it than just enough to make the structure all pearlite.

Let us now consider the changes that occur when steel is hardened. It is stated above that the iron, when at high temperature, has dissolved in it the carbon, in the form of carbide of iron. It must be understood that the iron does not have to be melted to do this. The familiar idea of a solution is a solid dissolved in a liquid; for example, salt and water. But in the case of metals, we must extend our ideas to take in the fact that one solid can dissolve another. The case hardening of iron, and the making of tool steel by the cementation process are well known examples of the dissolving of carbon in steel while red hot, but not melted. Such a solution is called a solid solution for obvious reasons. An excess acetylene flame played for some time on a piece of iron will put enough carbon into it to make tool steel of its outside surface. As the carbide of iron is not held in solution in cold iron, there must be some temperature below which it exists as carbide of iron. This temperature is about 1,300 degrees F. The change from the solid solution occurs in a 1 per cent carbon steel as follows: As the steel cools from the melting point, it solidifies by degrees through quite a range of temperature, say from about 2,660 to 2,180 degrees F.; at the latter temperature it is entirely solid, and is a solid solution of carbide of iron in iron. No further change takes place except that it becomes cooler as the temperature falls further, till 1,480 degrees F. is reached, when the excess cementite before mentioned falls out of solution, and the steel consists of a mass of grains of solid solution surrounding by films of cementite. When the temperature falls to about 1,300 degrees F., the grains of solid solution change into pearlite, and the structure is as shown in Photo No. 6. No further change occurs as the metal cools down to the ordinary temperature. The changes and temperatures given are correct only for 1 per cent carbon steel, but give an idea of what happens in all steels.

If we desire to see the structure of any steel at a high temperature, we may do so approximately by heating it to that point, and quenching it as suddenly as possible by plunging in ice water. The structure resulting is only approximate because it takes an appreciable time, even with liquid air, to cool the specimen, and during that time some change is occurring; still we gain much from such a procedure.

Photo No. 7 shows a piece of the same steel as in Photo No. 6, quenched in ice water from 1,800 degrees F. It shows what is called martensite, and is the structure of all quenched steels. Photo No. 8 shows a piece of soft steel quenched from 2,200 degrees F. in ice water. The structure is the same, but there is very little hardness to it, and it is easily machined, while the former piece (Photo No. 7) cannot be machined at all.

As stated before, the greatest difference between commercial steel and cast iron is that the former does not contain over about 1.5 per cent carbon, while the latter may contain from 2.25 to 4 per cent, while all the carbon in steel

[2]The difference in the size of the grains in the two photos is due to different heat treatments, and does not affect the accuracy of the statement.

Fig. 1. Longitudinal section of wrought iron welding wire. The black streaks and spots are slag. The grains are outlined by the dark lines, and are nearly pure ferrite. 200X.

Fig. 2. Boiler plate containing about 18% carbon. The ferrite grains are clearly outlined by the dark lines, but the dark spots at the grain boundaries are pearlite, and contain all the carbon in the steel. 200X.

Fig. 3. Same as Fig. 2, but at higher power. 750X. The pearlite spots show their laminated structure. The etching was not sufficient to show the grain boundaries. The rather rapid cooling of the plate has prevented the full development of the pearlite. 750X.

Fig. 4. Annealed 45% carbon steel. Ferrite at grain boundaries (F); pearlite in center of grains. The amount of ferrite becomes less, and the pearlite more as the carbon increases. 200X.

Fig. 5. Steel containing about 77% carbon; it is nearly all pearlite. The light plates are cementite, the dark ones, ferrite. The dark color of the ferrite is due to light and shadow effects; they are really nearly as white as the cementite. 1200X.

Fig. 6. Annealed 1.1% carbon tool steel. Pearlite grains surrounded by cementite films; there being more carbon than necessary to make pearlite, the excess appears around the grain boundaries. 1200X.

Fig. 7. 1.1% carbon tool steel quenched in ice water from 1800° F. The white plates or needles are martensite; the dark parts show that the cooling was not rapid enough to hold all the metal in the martensitic condition. 430X.

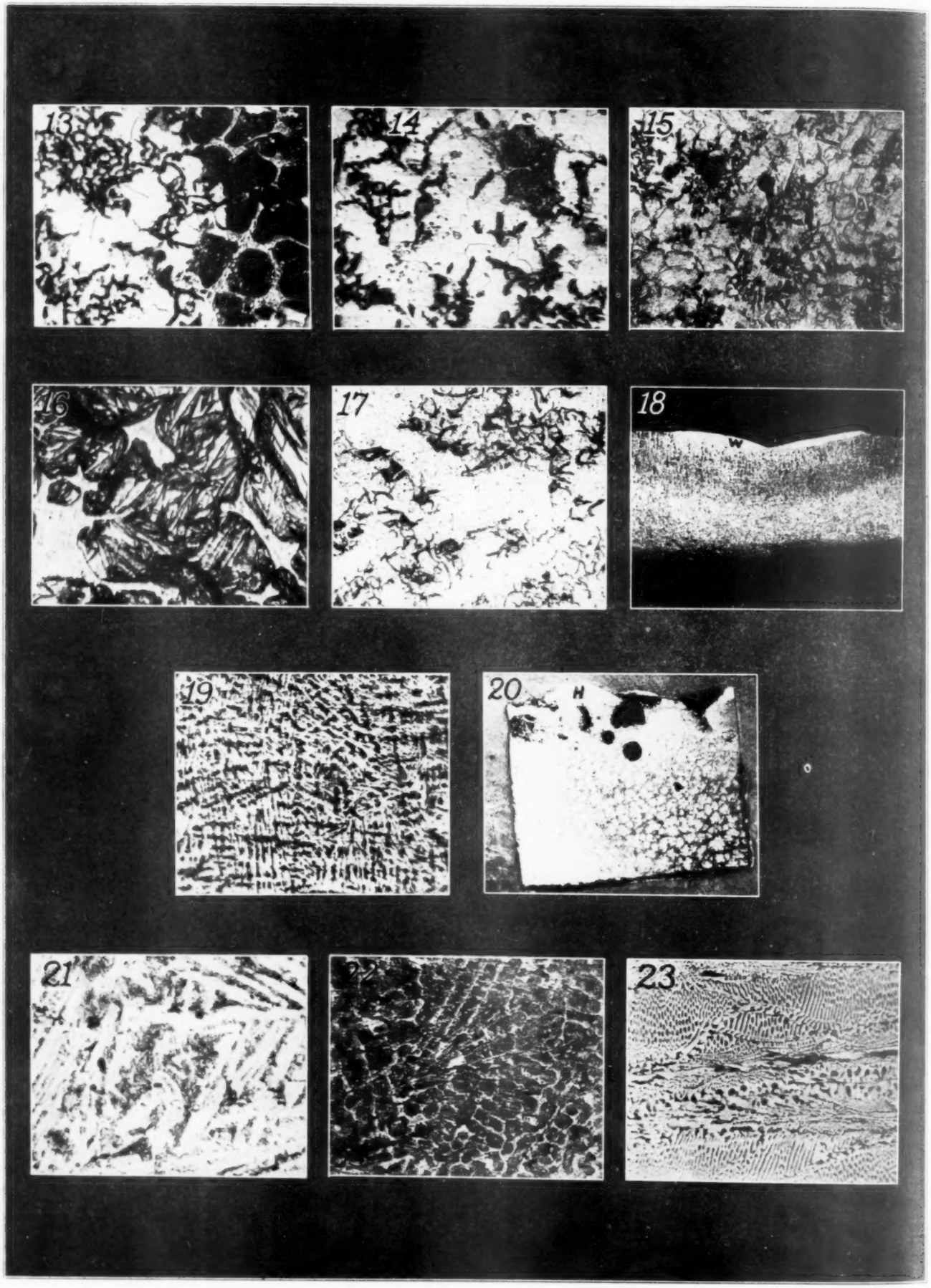
Fig. 8. 18% carbon steel quenched from 2200° F. in ice water. The structure is the same as with high carbon steel, but the low carbon permits the piece to be machined while the piece in Fig. 7 cannot be. 200X.

Fig. 9. Very soft cast iron. Ferrite grain boundaries show clearly. There is no pearlite. The large dark parts are graphite. 200X.

Fig. 10. Cast iron of Fig. 9 quenched from 1800° F. in ice water. Some of the graphite plates (dark streaks an spots) still remain, but the ground mass is martensite, as in Fig. 7. 200X. (The white spots contain the phosphorus in the metal, and are a eutectic of iron carbide, iron and iron phosphide, commonly called phosphide eutectic.)

Fig. 11. Same as Fig. 10, but showing the martensite more clearly at higher power. 430X.

Fig. 12. Cast iron of Fig. 9 heated to 1800° F. and cooled in furnace. This would be the structure of an ordinary casting. The grains are all pearlite. The black plate is graphite. (The white banded and dotted part is well developed phosphide eutectic.) 430X.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as in the shape of carbide of iron, in ordinary cast iron some of it is in the shape of graphite, which is just the same material as the black lead used in making pencils and crucibles. This soft friable material imparts its qualities more or less, in proportion to its quantity, to the cast iron, so that cast iron is softer and weaker than steel. This graphite is frequently called graphite or free carbon to distinguish it from the carbon existing in carbide of iron, which for obvious reasons may be, and sometimes is, called combined carbon.[3]

The action of other elements in cast iron, such as manganese, sulphur, phosphorus and silicon, is quite complicated; but one fact stands out clearly and that is that as silicon is increased, other things being equal, the iron becomes softer, because silicon promotes the formation of graphite, and of course prevents the formation of pearlite, this making the iron soft. As cast iron is an iron carbon alloy, just as is steel, it would naturally be expected that the rapidity of its cooling would have about the same effect on it as on steel, and this is the fact. Every foundry man knows that a small casting poured from the same ladle as a large one will be closer grained, harder, and stronger than the larger one. This is on account of the more rapid cooling in the case of the small casting. And as he also knows that silicon is a softener, he uses, or should use, less silicon in his large castings than in his small ones, if he desires the same quality of iron in both cases. Photo No. 9 shows a very soft piece of cast iron. Notice the large graphite plates, and the large proportion of the space they occupy; also the absence of pearlite. It is from a large casting and apparently the iron is high in silicon, and evidently was cooled slowly, allowing the full development of the graphite. Notice also that, aside from the graphite, the structure is the same as in Photo No. 1; that is, irregular grains with nothing between them.

Photo No. 10 shows the same iron heated to 1,800 degrees F. and quenched in ice water.

Photo No. 11 shows the same field at higher power; it resembles Photo No. 7.

Photo No. 12 shows the same iron heated to 1,800 degrees F. and cooled down with the furnace, which produces a structure similar to that of an average casting from the metal. This shows that very slow cooling was the cause of the large amount of graphite in Photo No. 9, and that the silicon is not unusually high.

Photo No. 13 is from a piece of welding rod. This is high silicon material, and as it is cast in small rods, it is rapidly cooled, and the structure is different from Photo No. 9.

Photo No. 14 is a piece of the same rod heated to 1,800 degrees F. and cooled in the furnace to resemble somewhat the cooling of an average casting.

Photos Nos. 15 and 16 are from a piece of the same rod melted and quenched in ice water.

[3] That is, combined chemically with iron, as carbide of iron.

Photo No. 17 is from the same rod heated to 1,800 degrees F. and quenched in ice water. It is so hard it cannot be filed.

Photo No. 18 shows a spot on the face of a piece of ordinary cast iron just melted with the torch and chilled by radiation and conduction. The photo is a section through the center of the spot, and the white edge is shown in Photo No. 19. It consists of cementite, the white material, and pearlite, the darker parts. It is of course too hard to machine or file.

Photo No. 20 shows a hard spot in a weld, a section having been made through it, while the structure is as in Photo No. 21. It is the same, though a little coarser, as in Photo No. 19. The hard spot is in the original material.

Photo No. 22 shows a piece of chilled iron, which has the same structure as the hard spots. The difference between the various pieces of cast iron shown above is in the rapidity with which the quenching has been done. Ordinary chilled iron is cooled no faster than any other sand casting, but in all cases of hard spots in chilled iron, the rate of cooling is about the same, and much less than that of the quenched pieces of cast iron shown so that there is time for the cementite to separate out as such instead of being partly held in solid solution and appearing as martensite, as in the quenched pieces of cast iron and steel. It therefore appears that the structure of either a piece of cast iron or steel depends with a given chemical composition upon the rapidity of cooling and the temperature from which it is cooled. The former is the more important of the two.

It should be noticed that the structures of both cast iron and steel are the same with the same heat treatment, that is, the same quenching treatments, with the exception of the size of the grains. The grain size is dependent upon a great many considerations, a discussion of which is not necessary at the present time, but in the cast iron will be found ferrite and pearlite as in steel, and if the graphite could be removed from the cast iron, and these spaces welded up, we would have steel; and so it is natural that heat treatment would have the same effect on the two metals. During the welding process, it is never possible to secure severe enough quenching to produce martensite; but the cooling is rapid enough at times to produce chilled iron, as is clearly shown in the photographs. It is quite clear from the photographs that even with a very high percentage of silicon, sufficient hard material, such as martensite or cementite, can be produced to make the metal hard. Silicon is quite readily burned out, and with its removal, the chilling properties of the metal are increased so that hard spots are caused by the rapid cooling of the metal aggravated by the removal of silicon by heating. Table No. 1 shows the average composition of ordinary machinery cast iron, of cast iron welding rod, and of chilled cast iron. The two important elements are the carbon and silicon. The carbon is the same in all three cases, while the silicon is lowest in the chilled

Fig. 13. Cast iron welding rod as received. The white is ferrite, the dark is very fine pearlite. The dark plates in the ferrite are graphite. The half tone spots in the pearlite are phosphide eutectic. The etching is deep enough to show the grain boundaries in the ferrite. 430X.

Fig. 14. Same rod as Fig. 13 heated to 1800° F., and cooled in furnace to resemble an ordinary casting. Mostly ferrite and graphite. One pearlite spot. The slow cooling has made much more graphite and ferrite than in Fig. 13. 430X.

Fig. 15. Same rod as in Fig. 13 melted and quenched in ice water. Even with this rapid cooling there is much graphite present, because of the large amount of silicon. The whitish ground mass is mostly martensite. The irregularly shaped white spots are probably phosphide eutectic (not well developed), and cementite. 430X.

Fig. 16. Same as Fig. 15, but at higher power. 1200X. The martensitic structure is very clear. This piece is glass hard. Compare with Figs. 7, 10 and 11. 1200X.

Fig. 17. Same rod as in Fig. 13 heated to 1800° F. quenched in ice water. The structure is about the same as in Fig. 15, but there is more graphite, because of the lower quenching temperature. 430X.

Fig. 18. Section through spot on piece of cast iron, heated just to melting point and allowed to cool in air. The quenching by the cold iron around the melted spot was very rapid. The white layer (W) on top, has had some of the silicon burned out, and the rapid cooling has made white, or chilled, iron. 3X.

Fig. 19. Structure of white layer of Fig. 18. The white is cementite, and the dark, pearlite. 430X.

Fig. 20. Hard spot, H, in a weld. This is in the original metal. 4X.

Fig. 21. Structure of hard spot in Fig. 20. It is the same, cementite (white), and pearlite (gray), as in Fig. 19, but coarser because of the longer application of the heat. 430X.

Fig. 22. Chilled cast iron. The white is cementite and the ground mass, gray, is pearlite. 100X.

Fig. 23. Eutectic of iron and carbon. 4.3% carbon. The white is cementite, the dark is pearlite. Notice the banded and dotted structure, which is similar to that of the phosphide eutectic in Fig. 12; also, its partial resemblance to pearlite, Fig. 6. 200X.

iron and highest in the welding rod. The large amount of silicon in the welding rod permits of some of it being burned out, and also of rather rapid cooling before the weld will become unmachineable, but in the case of machinery iron, the amount will not prevent hard spots, because some of it will be burned out, and because the original material is not brought to so high a temperature as the weld, so that its cooling is more rapid than that of the weld. For these reasons, hard spots are usually in the original material and not in the weld.

The remedy for, or rather the avoidance of, hard spots is simple. The weld material should be piled up a trifle above the edge of the V and the original material melted together with the added material, and the two allowed to run together. This not only increases the temperature of the original metal next the V, but allows some of the silicon from the weld to pass into the melted original, thus keeping it soft. The fact that silicon is rather easily burned out of cast iron also shows the necessity of not keeping the heat on it during welding any more than is necessary.

These conditions all being within control of the one doing the welding, it is, as one of the correspondents of *The Welding Engineer* has truly said, "entirely up to the welder."

It may be of interest to note in Fig. 23 the eutectic alloy of iron and carbon which contains 4.3 per cent carbon, and which melts at 2,075 degrees F., while pure iron melts at 2,730 degrees F.

TABLE NO. 1.

Elements	Machinery Iron Per Cent	Welding Rod Per Cent	Chilled Iron Per Cent
Carbon	3.50	3.50	3.50
Managanese	.80	.50	1.00
Sulphur	.09	.05	.05
Phosphorus	.60	1.00	.18
Silicon	2.00	3.25	.90

APPLICATION OF ELECTRIC WELDING TO SHIPBUILDING.

Although electric welding has been employed for many years for ship repair work, its use has been confined to those parts of the structure that are not likely to be exposed to important stresses. However, the more advanced ship builders recognized that this method of construction offered almost endless possibilities and brought the matter to the attention of Lloyd's Register which arranged to carry out an exhaustive series of tests that extended over a period of six months.

One of the most important problems in shipbuilding is the joining of mild steel containing about 0.15 per cent carbon to the other structure. This material, in the process of manufacture, has been worked until it possesses a fine structure, its ductility is uniform in every direction, and it is practically free from fibrous structures. With electric welding, molten metal is attached to the mild steel and is cooled so rapidly that the weld tends to become deficient in ductility. The problem therefore is to select the material of the electrode so that the general elastic properties of the structure are not unduly depreciated.

The general scope of the experiments included the determination of the modulus of elasticity and the approximate elastic limit; the determination of the ultimate strength and the ultimate longation; the application of alternating stresses with both rotating and stationary test pieces; cold-bending of welds, and impact tests of weld specimens; also chemical and microscopic analyses.

Results of Tests.

The tests showed that the elastic limit appears to be slightly higher in the welded than in the unwelded material. The modulus of elasticity of a small piece composed entirely of material of the weld was about 11,700 tons per square inch as compared with about 13,500 tons for mild steel and 12,500 tons for wrought iron. The ultimate strength of small welded specimens was over 100 per cent of the strength of the unwelded steel plate for thicknesses of ½ inch and average 90 per cent for plate ¾ and 1 inch thick. Up to the point of fracture, the extensions of the welded specimens are not sensibly different from those of similar unwelded material. At stresses greater than the elastic limit, the welded material is less ductile than mild steel and the ultimate elongation of a welded specimen, measured on a length of 8 inches, is only 10 per cent, as compared with 25 or 30 per cent for mild steel. Welded specimens are not capable of being bent without fracture over the described radius for more than 80 degrees with ¼-inch plate, and the bend is reduced to about 20 degrees in the case of 1-inch plate. Unwelded material under the same conditions can be bent to 180 degrees. Welded plates can successfully withstand considerable impact.

The chemical and microscopic analysis showed that the material of the weld after deposition is practically pure iron, though it contains 0.03 per cent carbon, 0.02 per cent silicon, 0.02 per cent phosphorus, and 0.04 per cent manganese. The local effect of heat does not appear to affect the surrounding material greatly, and the structure is not disturbed about ⅛ inch from the edge of the weld. There is little if any evidence of oxidation.

Butt welds have a tensile strength of 90 to 95 per cent in welded plate. Lap welds with fillets on both edges have a tensile strength of from 70 to 80 per cent of the unwelded material. Riveted lap joints for plates ½ inch thick have a strength of 65 to 70 per cent of the unperforated plate. Broadly speaking, the tensile strength of large butt welds is as great as the unwelded material, but it is considered that greater reliability of workmanship is obtained with joints that are either lapped or strapped. It was also found that the lap joint is about as strong as the riveted lap joint, and will withstand more trying conditions than the riveted lap joint.

Regulations of Lloyd's Register.

After full consideration of the subject the committee decided to recommend that probational rules should be adopted for the application of electric arc welding to shipbuilding, and that the approval of the society should be given to any process that complies with these regulations. These rules provide that before welding, the surfaces to be joined must be fitted close to each other and that all butt and edge connections are to be lapped or strapped. With lap connections the breadths of overlaps of butts and seams and the profiles of the welds are to be as follows:

Thickness of Plate, Inch	Width of Overlap Seam and Butt, Inches	Total Thickness Inch
0.40 and under	2¼	0.28
0.60	2½	0.38
0.80	2¾	0.48
1.00	3	0.50

Intermediate values may be obtained by interpolation and for thickness below 0.4 inch plate, the thickness is to be about 70 per cent of the thickness of the plate.—Iron Age.

MAIL ORDER WELDING COURSE.

We are in receipt of a booklet issued by the International Correspondence Schools, Scranton, Pa., in Gas and Electric Welding. This mail order course is very incomplete and elementary, if we are to judge by the bulletin (No. 1414) received.

DISCUSSION *of the* MERITS *of* BOTH CHARCOAL *and* GAS PREHEATING

By Fred J. Maeurer*

IN preheating castings where *expansion* and *contraction* must be taken into consideration, there seems to be a wide difference of opinion as to which is the best fuel to be used, charcoal or gas, and the writer having had considerable experience with both kinds and methods for a number of years, recommends the use of charcoal in its entirety, for this type of casting, and will try to explain his reasons for believing so, and as cast iron is the metal that gives the greatest amount of trouble, will not touch on any others at this time, such as bronze, copper, steel, brass or aluminum.

Cast iron is a peculiar metal—more so than others—and is classed as a poor conductor of heat, is devoid of elasticity and elongation, therefore, will fracture a great deal easier than other metals when attacked by strains or stresses. When this type of casting comes to the welder for repairs it is always necessary to remember that expansion and contraction will cause fractures if the shape of the piece opposes free play in heating or cooling, and, therefore, it is very essential that special precautions be taken to avoid these fractures, and to overcome them, preheating naturally is a necessity.

Fig. 1. Heavy Casting, Protected by Fire-brick Furnace, Being Preheated.

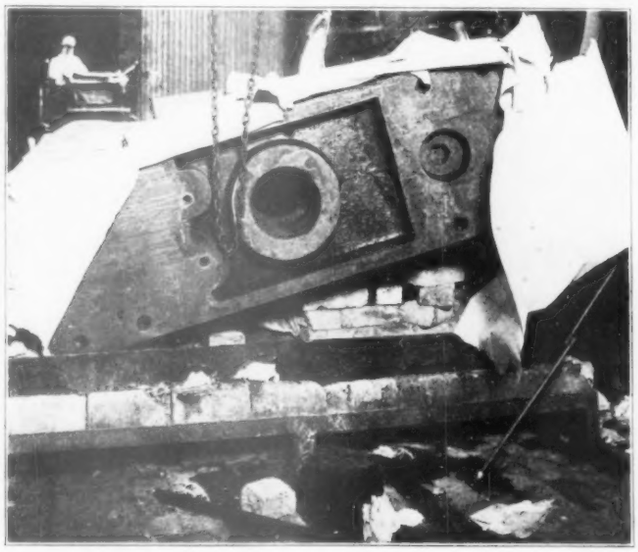


Fig. 2. Figs. Nos. 4 and 5 Show How This Casting Was Prepared.

Figs. No. 1 and No. 2 fully illustrate the type of castings referred to and these are only two of the many thousands of their kind that are being welded and have been welded in the past, and which have made welding an absolute necessity in every large plant in the United States, and that played so important a part to help win the war.

After planning in advance what way these castings would best be preheated, we set them up on brick about twelve inches from bed of table on floor, supporting casting on all corners, also in center, to prevent warping and sagging from its own weight or from heating, then built a fire brick wall all around casting, setting brick about half an inch apart to give sufficient draft, put a layer of charcoal on floor of table underneath casting and light same, then covered entire casting with asbestos paper to retain heat and keep off all drafts, and after the casting slowly warmed up additional charcoal was added until the casting was fully heated and ready for welders.

After these castings have been preheated and welded, it cannot be too strongly impressed on the welder's mind that *slow cooling* is an absolute necessity, and additional charcoal should then be put around casting which brings it up to a greater heat, and then starts to cool slowly and evenly. This method also thoroughly anneals casting, distributes and equalizes all strains and stresses that were originally in casting or were imposed by welding, also that which is always desirable and necessary—a joy to both the welder and customer—secures a soft and machinable cast iron weld, and it cannot be denied that on this type of casting charcoal used for preheating alone will give all these desired necessities—and what is more to the point, all these are absolutely essential where success is desired.

In selecting charcoal for preheating purposes only hard wood grades are desirable, and should be used, as this grade does not give off any offensive fumes or odors, burns without smoke, burns slowly and evenly, needs no fans or blasts, is readily and easily controlled, and will heat any kind or type of casting evenly and slowly, to any desired temperature, and last, but not least, allows the casting to cool slowly and evenly, retaining heat from twenty-four to forty-eight

*Superintendent Chicago Shops, Davis-Bournonville Co.

Fig. 3. Here We Have the Finished Result of Fig. No. 1.

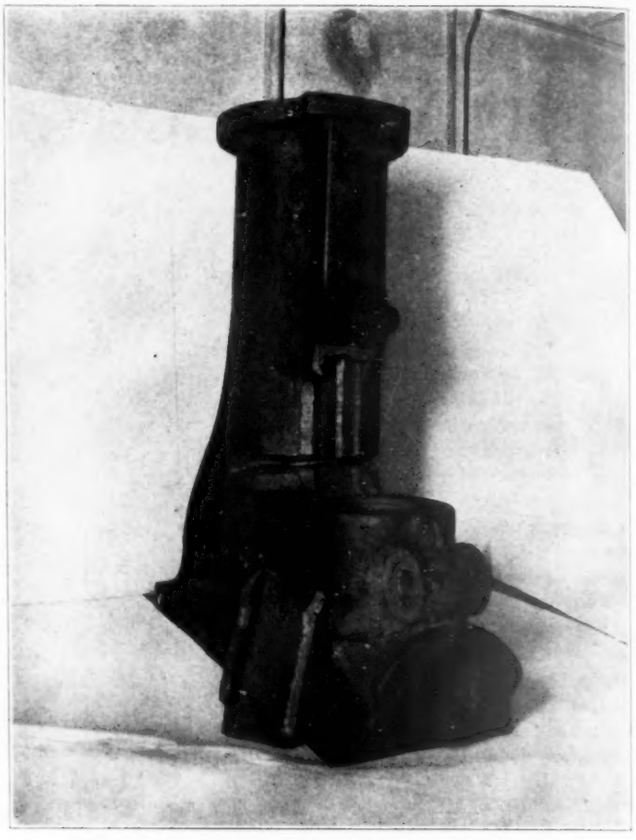


Fig. 4. A View of Fig. No. 2, Showing Preparation.

hours. Fig. No. 3 shows Fig. No. 1 completed and in running order, and Figs. Nos. 4 and 5 show how Fig. No. 2 was prepared and how it looked after welding. Both of these castings have been in service for more than two and a half years, and have not been disassembled since welding was completed, and castings restored to machines.

The main objection to the use of a gas flame or flames for preheating lies in the fact that it is impossible to retain heat in a large casting while it is being welded, due to the fact that it is necessary to shut off gas flames while the welders are operating, as immediately upon shutting off heat supply casting starts to cool and contract on one side, while

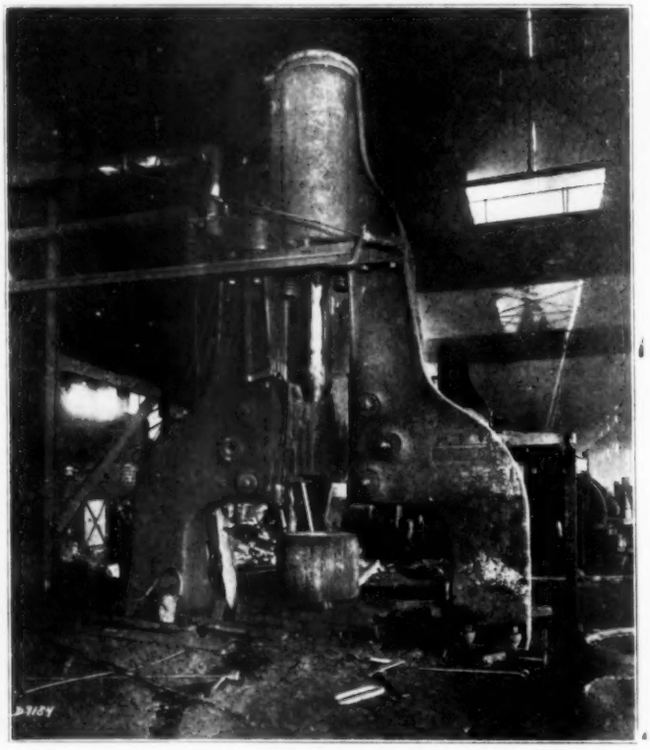


Fig. 5. Another View of Fig. No. 2.

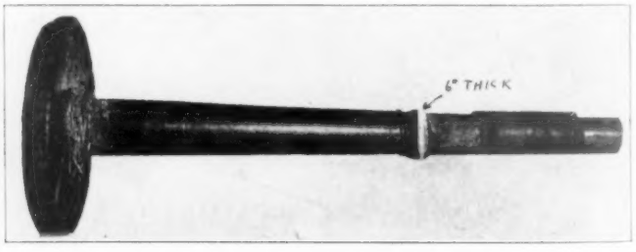


Fig. 6. A Large Casting Successfully Preheated.

the welders are soaking in more heat and expanding casting on other side with their welding torches, therefore, setting up opposite each other the two extremes of cooling and contracting, and heating and expanding, and when you do this it is only a question of which one of the two has the greater strength, and if the casting does not fracture then and there, it surely would when subjected to test, or received a hard jolt through handling, loading or unloading, due to the

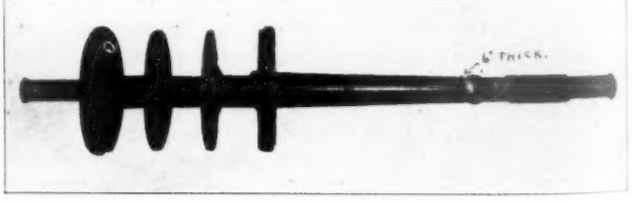


Fig. 7. Another Large Casting Successfully Preheated.

strains and stresses set up by too fast cooling and uneven heating. This same rapid cooling tends to bring about the combination of the carbon and iron, and forms what is called white iron, this same white iron being very brittle and having little or no strength.

In fact, the writer has in mind several instances that have come to his attention in the past, where castings that had been preheated by gas flames had broken several days after welding had been completed, and were thoroughly cooled, fracturing occurring while they were lying on shop floor, these fractures being caused by the strains and stresses being set up in casting through too fast cooling. Gas flames are advantageously used in a great many cases too numerous to mention where expansion and contraction play no vital part, and no modern shop is complete without both systems. Figures Nos. 6, 7 and 8 clearly show large castings that have been successfully welded, and were preheated by gas flames.

The writer does not wish to create the impression in the minds of his readers that preheating a casting with charcoal alone guarantees a successful welding job, as this is not a fact; a casting can be properly preheated and cooled, the methods may be accurately planned in advance, in fact, properly taken care of before and after welding, but there are other things to be taken into consideration besides preheating, which I will try to explain. The greatest essential is to use properly constructed and reliable apparatus, and the best grade of welding materials. The concerns selling cheap grades of welding materials tell us that by purchasing a lower priced rod it cuts down the cost of welding operations, but to the

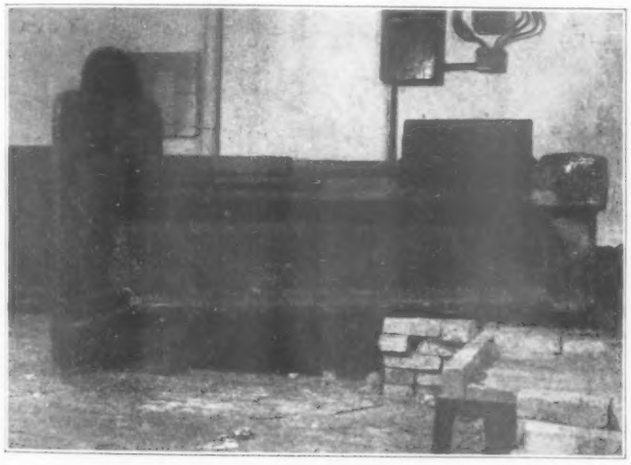


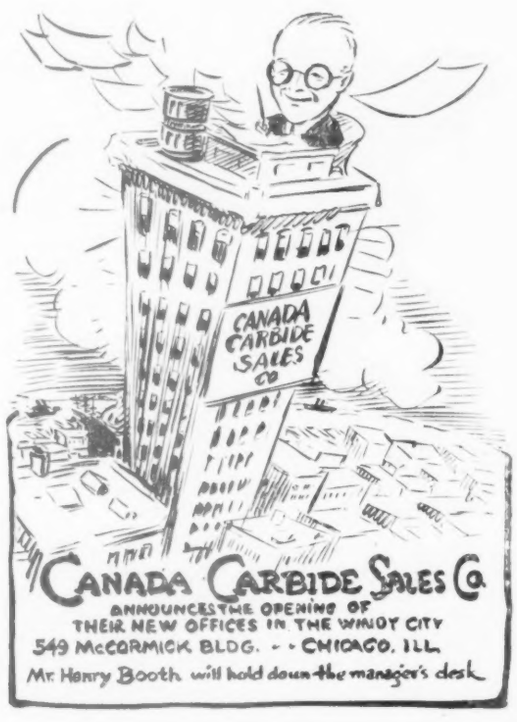
Fig. 8. A Large Casting Preheated with a Gas Flame.

welder in the shop who knows welding costs it is a huge joke, as the welding materials used do not constitute 5 per cent of the welding cost, the balance being made up by labor, gases etc. The writer knows this to be a positive fact, and contends that the best is none too good where a sound and strong weld is desired. This applies to any kind of a weld, and should never be lost track of; for instance, will say the tensile strength of the metal to be welded is 50,000 lbs. per square inch, it certainly isn't logical to assume that a good sound weld can be made when the tensile strength of the welding rod is only 15,000 lbs. per square inch; it also does not follow that a wire used for tying up bales of hay is good welding material. The rod melted and fused into a weld by the welders must contain ingredients that counteract detrimental effects caused by the welding flame, and that will replace certain elements destroyed by the flame, and to get a rod of this kind economy should be forgotten and a sound weld kept in mind instead. The only way you can get a rod with these proprieties is to purchase it from high grade manufacturers, who have made a complete and exhaustive study of this and who can sell you rods whose analysis have been carefully determined by their metallurgists.

The use of the best apparatus obtainable is of vast importance. It is a known fact that no workman can turn out good workmanship with a poor set of tools, and the writer can frankly state that many a good weldable casting has found its way into the scrap heap which could have been saved had high class apparatus been used, and the big manufacturers, mills and shipyards have found this to be only too true.

Many firms will buy any kind of apparatus because it is cheap, but if you try to sell them a $10.00 micrometer for $6.00, they will immediately want to know *what is the matter with it.*

A torch that cannot maintain a neutral flame for the length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ANNOUNCES THE OPENING OF
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549 McCORMICK BLDG. - - CHICAGO, ILL.
Mr. Henry Booth will hold down the manager's desk

of a big welding job without constantly changing is absolutely worthless and should be relegated to the scrap heap, and by so doing you start to save money at once and ward off trouble at one and the same time, and unless your torch does maintain a neutral flame it is impossible to make a good weld. This cannot be too strongly brought out, as an excess of oxygen will oxidize or burn a weld, resulting in a hard, brittle weld that will not stand any strain whatever. An excess of acetylene will carbonize the weld, leaving the metal spongy and porous and will not approximate the strength of the original metal.

As an illustrationu, the casting shown in Figures 2, 4 and 5 must stand a high steam pressure and if the weld is spongy, porous or too hard the weld would not hold and the resultant loss in time, labor and production would amount to more than the cost of high class apparatus, and the best welding material obtainable.

BOILER MAKERS' CONVENTION.

The Master Boiler Makers Association Convention will be held at the Hotel Sherman, Chicago, May 26 to May 29th, 1919.

The Railroad Administration has authorized this meeting and it will be the largest convention ever held. It is expected that there will be at least 1,000 Foremen Boiler Makers of the leading railroads of the country present.

WELDING A CLUTCH PULLEY.

As I have derived a great deal of benefit from reading weld. This cannot be too strongly brought out, as an ex- articles that appeared from time to time in The Welding someone.

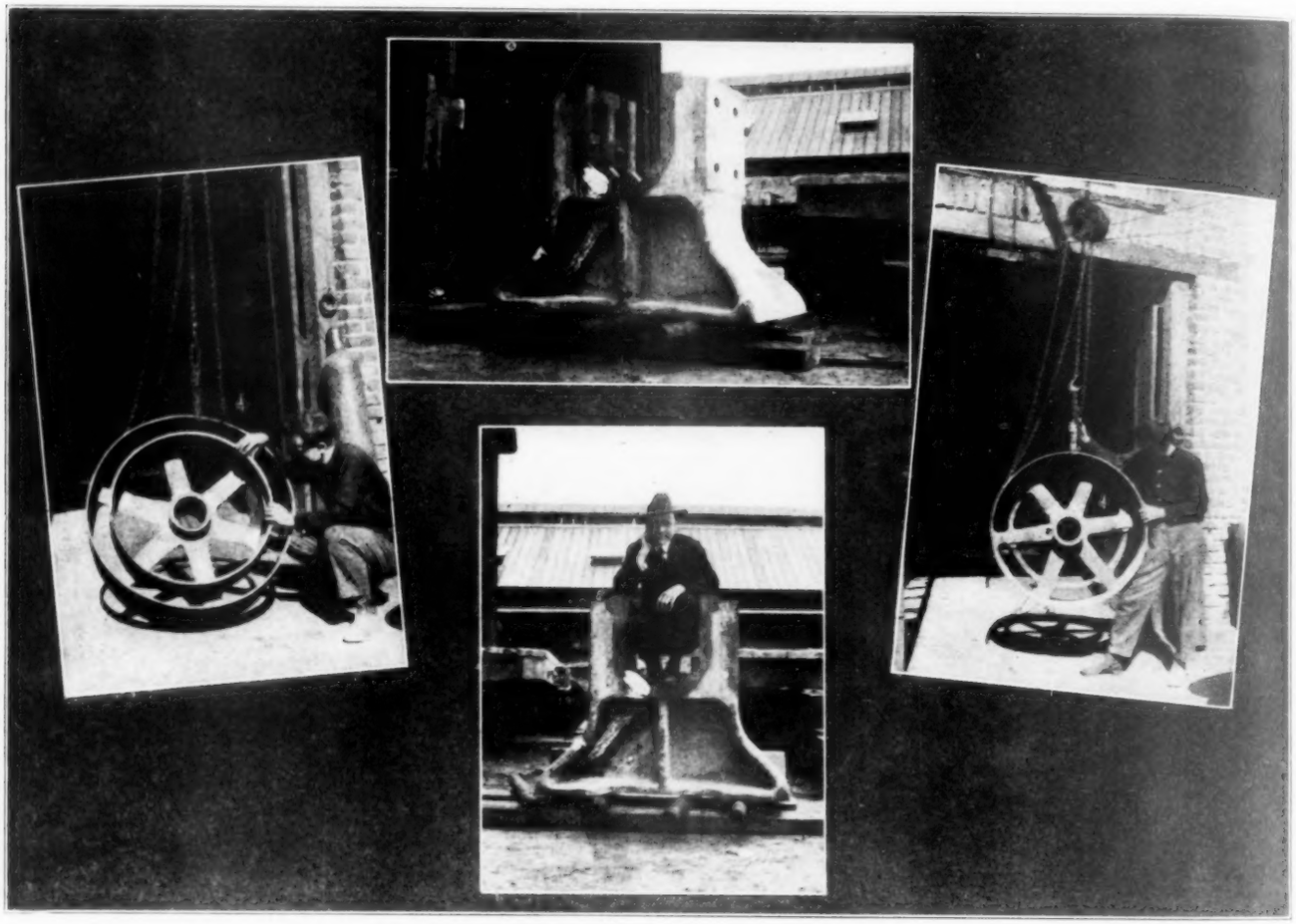
We welded for the Charleston, S. C. Mining and Mfg. Co., of Lambs, S. C., a three feet clutch pulley, and a twelve inch crank shaft pedestal weighing about three thousand pounds. Both jobs were guaranteed, and are doing their bit at this writing.

The clutch pulley was welded in the following manner:

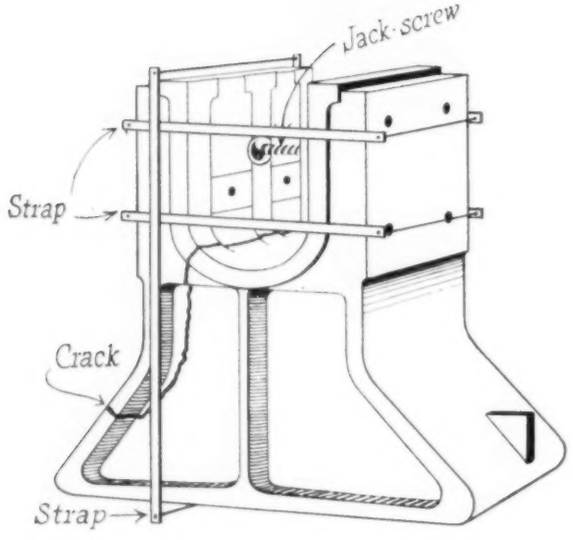
First, we used a portable emery to do the grinding. The spokes being about two inches thick and four inches wide, we ground all the way through, forming a forty-five degree bevel.

We then put six supports under outer rim, and four under inner rim, also one under the hub. Then built a portable fire brick furnace around same, allowing a six inch clearance around and above.

We left four holes on each side at the bottom for draught,



Welded for the Charleston Welding Works, Charleston, S. C., by James Hahn.



then filled furnace up with three barrels of charcoal, using two gallons of kerosene to light same, and covered with asbestos. Heating time, six hours; welding time, two hours. Used a Davis-Bournonville water cooled torch. We did all the welding from one side, doing away with two pre-heats. Did not use a blow torch for pre-heating, as we believe that a slow, steady fire was better in this case. It took forty-eight hours to cool off sufficiently to remove from furnace; there was no dressing to be done.

The pedestal was done in the following manner:

First we strapped the arm with three straps, as per illustration; then used a chipping gun for the necessary forty-five degree bevel.

As it was two inches thick, we beveled from both sides where possible. The job had to be pre-heated four times, as it was necessary to make four welds and shifts. Used twenty-four barrels of charcoal, ten gallons of kerosene, one hundred pounds cast iron rods, and one pound of flux; also a Davis-Beurnenville water cooled torch.

Both of the jobs were welded and guaranteed.

—James Hahn.

THE USE *and* MISUSE *of* OXY-ACETYLENE EQUIPMENT

By C. J. Nyquist*

GAS STORAGE AND DISTRIBUTION.

THE storage of oxygen and the distribution of oxygen through pipelines is quite similar to air storage and distribution, except that oxygen deteriorates the lines sooner and that greater precaution must be taken to avoid losses due to leakage. If welding is what we claim for it, it is certainly advisable to weld low pressure storage tanks and the pipeline joints. Water traps in pipelines must be guarded against and the lines should be well supported in order to avoid strains on them.

It is not advisable to use large storage tanks for acetylene, at least not inside a factory. It is, of course, necessary to use acetylene gas holders and comparatively small pressure compensation tanks, but they should preferably be placed outdoors. Acetylene distributing lines must, and for obvious reasons, be made tight and kept tight, which also applies to all cocks, valves, gauge connections and water seals on the lines.

Testing for leaks should not be made with lighted matches or any kind of flames. While there might be a difference of opinion as to the risk of flame tests, especially under certain favorable conditions, it is nevertheless bad practice to use open flames for testing leaks of inflammable gas. It is quite true that pipelines filled with acetyleme and even acetylene generators containing acetylene under pressure have withstood intense fire with only slight external damage. This only proves, however, that the gas in them happened to be pure, which is not always the case. Furthermore, it is necessary to take chances when it is just as easy to test for leaks by the use of soap water. Pressure storage tanks and gas pipelines should be provided with pressure gauges, and check test made regularly to make certain that the gas distributing systems are free from leaks.

Manifolding acetylene cylinders must be limited to tubing of very small diameter. A pressure on the acetylene in the ordinary pipelines exceeding 15 pounds per square inch is not permissible, under present regulations. Oxygen cylinder high pressure manifolds are convenient and safe provided the piping, fittings and valves used are of sufficient strength to stand the full initial cylinder pressure, or in other words not less than 2,000 pounds per square inch plus a proper safety margin. It is worth while to spend the money for a real manifold, a cheap one may prove to be altogether too expensive.

Flash-back preventers in gas pipelines generally depend for their operation on water seals, and it is, consequently, obvious that the operator must see to it that the water in them is continuously kept at the proper level. Some gas welding systems require individual water sealed flash-back preventers for each welding station. These must also, of course, be kept in good working condition and possible cracks or leaks due to freezing of the water in winter time or rough handling must be repaired or the damaged water seal replaced before using the station.

*President, Torchweld Equipment Co.

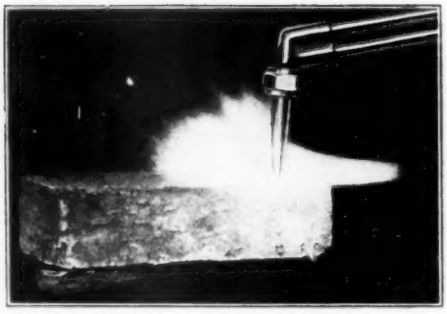
REGULATORS AND TORCHES.

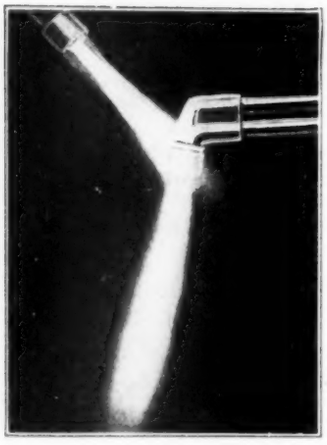
The most neglected parts of the oxy-acetylene welding and cutting equipments are generally the gas pressure regulators and the torches. Many operators entirely disregard the instructions given them regarding the use and the care of these instruments. Welding should be recognized as a trade but there certainly must be some requirements demanded of welders besides the ability to weld metals. Any welder worthy of the name should be familiar with the construction of the apparatus intrusted to his care, and should feel obliged to use them with the same care and consideration as the mechanic uses his machinery, tools and instruments. Just as easily as one can distinguish the scrub machinist from the real, dependable mechanic by the quality of his work and by the way he keeps his tools in order, so can the good welder and cutters be told from the metal melters and burners. It is a joy to find welders and cutters who take good care of their apparatus and fortunately many of them do. Any fair minded welder or cutter will, I am sure, agree with me that it is deplorable how some of this apparatus is handled. Look into some tool boxes and bench drawers, and you will find regulators, torches, tips, wrenches, spikes, bolts, nuts, scrap iron and what not all in a jumble and disorder. On the other hand the welder and cutter who actually takes his work seriously also takes a pride in having his apparatus in first class order.

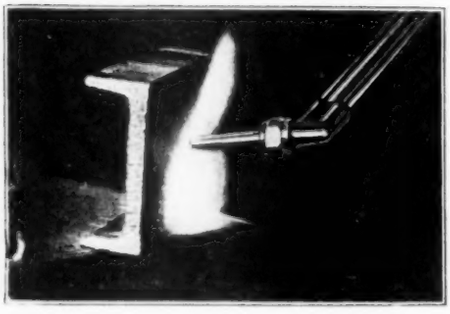
The gas pressure regulators are designed to reduce the initial gas pressure to a desired working pressure and to maintain that pressure. That is certainly not done by forcing the adjusting screw against the springs and the diaphram clear up to the thread limit and then checking the gas flow by the torch valves. The most common types of regulators have the seat holder connected to the diaphragm. When the spring pressure is applied the regulator seat is held a considerable distance away from the regulator nozzle. If then the gas is suddenly driven into the regulator the pressure against the diaphragm forces the seat violently against the nozzle and the result is often a damaged regulator seat. Unfortunately the cylinder valves in use do not provide for this condition, and it is, therefore, necessary to release the spring pressure on the regulator diaphragm before the gas pressure is admitted into the regulator and to open the cylinder valves slowly. A gas pressure regulator should be set at the desired working pressure when operating and the spring pressure on the diaphragm relieved when the cylinder pressure is shut off. Another reason why cylinder valves should be opened slowly is that the severe and sudden pressure on the gauges is apt to strain them. The regulator gauges, especially the hight pressure oxygen, should be provided with safety outlets to prevent damage in case of leaking gauge springs.

Oxygen regulators must be kept free from oil, as oil in a regulator is apt to ignite under heavy oxygen pressure. Dirt, sand, metal chips or other solid matter caught be-

WELDING AND C







JUDGE BY YOUR TEST

The three illustrations on the left are **actual photographs** of tests to which we put the REGO Model "L" welding torch. Of course, the photographs might be retouched or some trick of operation might allow us to make these tests without flashing the torch.

BUT—we guarantee you can do **the same thing in your own shop** and if you flash the torch, you may send it to us and **get your money back.**

This Company gets your interest by its advertising and our advertising **must** be truthful because we wholly depend on re-orders. If REGO torches didn't do as we claim, there wouldn't be any re-orders.

The elimination of the costly flashback isn't the only accomplishment of the REGO line of welding torches.

Absolutely equal proportions of oxygen and acetylene are consumed, effecting a considerable **saving in oxygen** bills and making **better steel welds,** free from excess sparking and froth.

Lower pressures are used, resulting in a **soft flame,** melting and uniting the metal without blowing or "sweeping" the line of welding.

Up to the advent of the REGO line, the balanced pressure principle of the REGO was new. The U. S. Patent Office, in granting a method patent covering this principle, sustains this contention.

We want you to know all about the REGO line. Our literature is free and there isn't a shop in the country to whom we will not extend the privilege of proving our claims.

There are real technical reasons why **the REGO principle is correct**—you can learn these reasons from our literature.

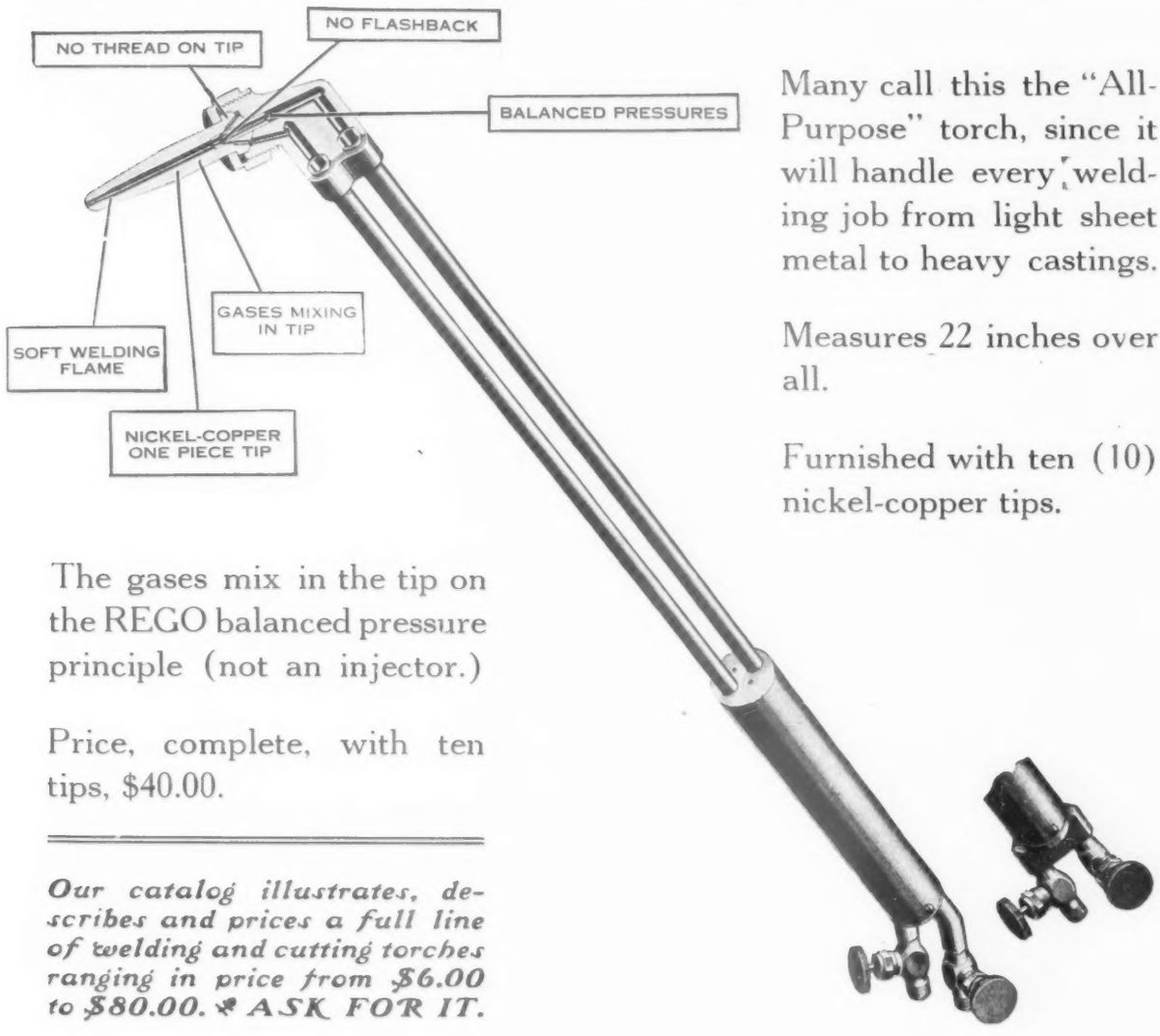
You can prove them by using the torch.

THE BASTIAN B
WEST AUSTIN AVENUE

TING APPARATUS

REGO MODEL "L" WELDING TORCH

For Acetylene (tank or medium pressure generator)



Many call this the "All-Purpose" torch, since it will handle every welding job from light sheet metal to heavy castings.

Measures 22 inches over all.

Furnished with ten (10) nickel-copper tips.

The gases mix in the tip on the REGO balanced pressure principle (not an injector.)

Price, complete, with ten tips, $40.00.

Our catalog illustrates, describes and prices a full line of welding and cutting torches ranging in price from $6.00 to $80.00. ASK FOR IT.

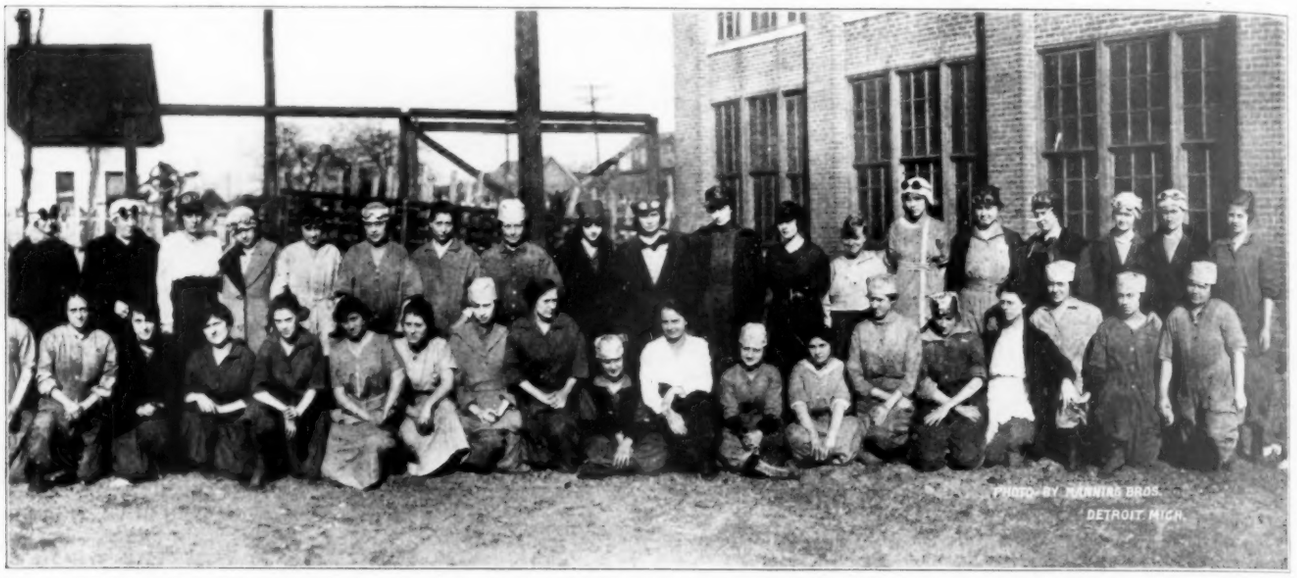
BESSING COMPANY

LA SALLE STREET CHICAGO.

tween any regulator seat and nozzle often results in leaking and creeping regulators.

On the construction and condition of the welding and cutting torches depend largely the results obtained by the oxy-acetylene process. The safety of operation is even more important. It is, therefore, evident that considerable

In properly designed and constructed torches the gas inlets in tips and gas mixing devices are drilled to exact sizes. Changing of these holes or bores by re-drilling or reaming invariably results in trouble. If necessary to clean them a soft wire should be used. The tips are often damaged by being either reamed too large at the outlet or upset so



During the War Mr. W. D. Grant, of the Detroit Prest-O-Welding Co., Instructed a Class of 75 Girl Welders.

care should be given to the right selection of the torches. As the process is comparatively new and in a state of development, all of the apparatus used is subject to improvement. There is nevertheless a considerable difference between a real torch and some brass goods sold under the same name and recommended for the same purpose. The

that the holes become irregular or partly closed.

Torch valves should be kept in good condition and the packing nuts on the needle valves drawn up fairly tight to avoid gas leakage. Metal seated swivel hose connections are better than stationary hose nipples, but must be so designed as to give an absolutely tight seat under

These Girls, and the Girls in the Illustration Above, Did Very Well Indeed. They Welded War Materials. The Most of Them Did it Because They Were Patriotic.

most undesirable features of some torches are, flimsy construction, their detendency to flash back, poor gas mixture, unhandiness and excessive weight. Leaky joints, tip seats and hose connections are the causes of much trouble. But even the best torches will not last long or give satisfactory service unless they are given reasonable care.

any pressure used. The hose must be securely fastened by wire or screw clamps to the hose connection. Shellac or rubber cement may be used to insure a leak free joint between the hose and the connection nipple, as leakage at this point results in considerable loss of gas and sometimes in bad burns.

(To be continued.)

Here's Information You Need!

In view of the modern trend toward welding as a means of labor, time and money saving, and the positive superiority of ***ARMCO IRON*** filling material, every well posted welding engineer should have this book of valuable information at hand for quick reference.

Send for your copy

"Armco Iron Welding Rods and Wire" is not merely a catalog, but treats in a helpful way of the following subjects:

Requisites of a desirable filling material.

Welding of mild steel and wrought iron.

How and why the new American product ARMCO IRON surpasses the now unobtainable genuine Norway and Swedish irons as a welding material.

How a single composition of ARMCO IRON supplants a large number of compositions of other welding materials.

Analysis and physical tests of ARMCO IRON.

Typical examples and illustrations of welding done with ARMCO IRON.

Emergency Fleet Corporation specifications for welding wire.

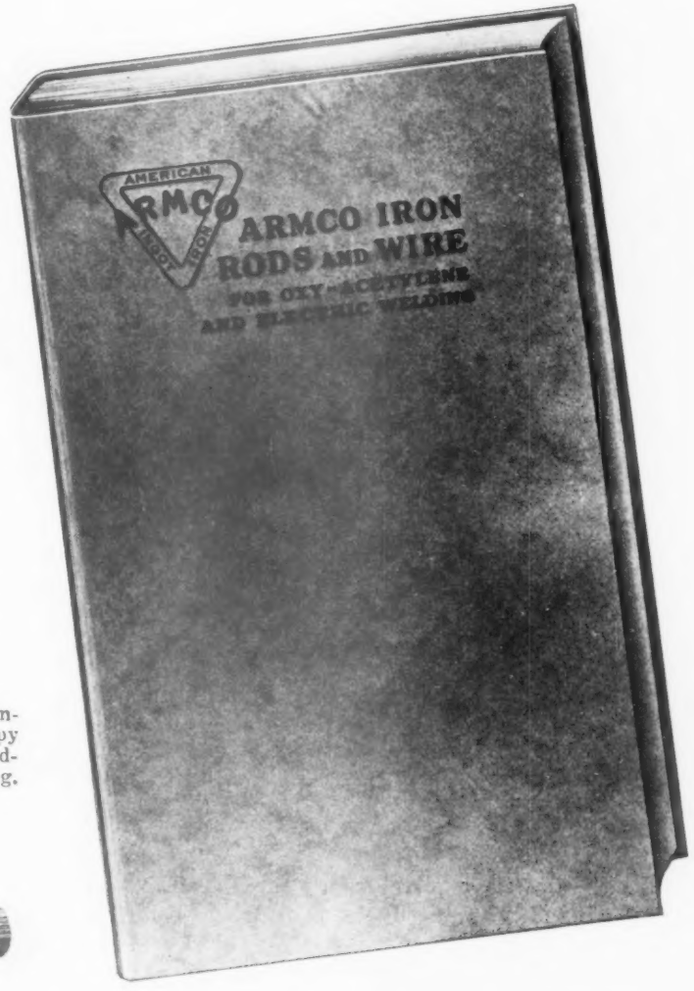
Microscopic study of steel and iron with reference to welding.

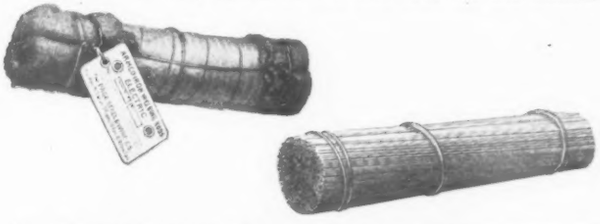
Cost cards for keeping tab on welding jobs.

Metallurgy of iron and steel, including color chart for heat treatment.

Miscellaneous useful data including tables of wire gauges, conversion of temperatures from Fahrenheit to Centigrade, properties of elements and metal compositions, decimal equivalents, metric conversion tables, definitions of electrical units, mensuration factors.

If you are a consulting, designing or managing engineer, shop superintendent or foreman, your free copy is ready for mailing on request, and the engineering advice of our welding specialists is also free for the asking.





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Makers of "Copperweld" Copper Clad Steel Wire; ARMCO Iron Welding Rods and Electrical Wire; Wire Mill Products, Plain and Galvanized; Wire of Special Analysis; Wire Fencing for all Purposes; Factory Gates; Ornamental Iron Fence; Machine Guards; Tool and Stockroom Partitions; Architectural Iron.

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Sales Offices: 30 Church Street, New York

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WELDING A LOCOMOTIVE CYLINDER.

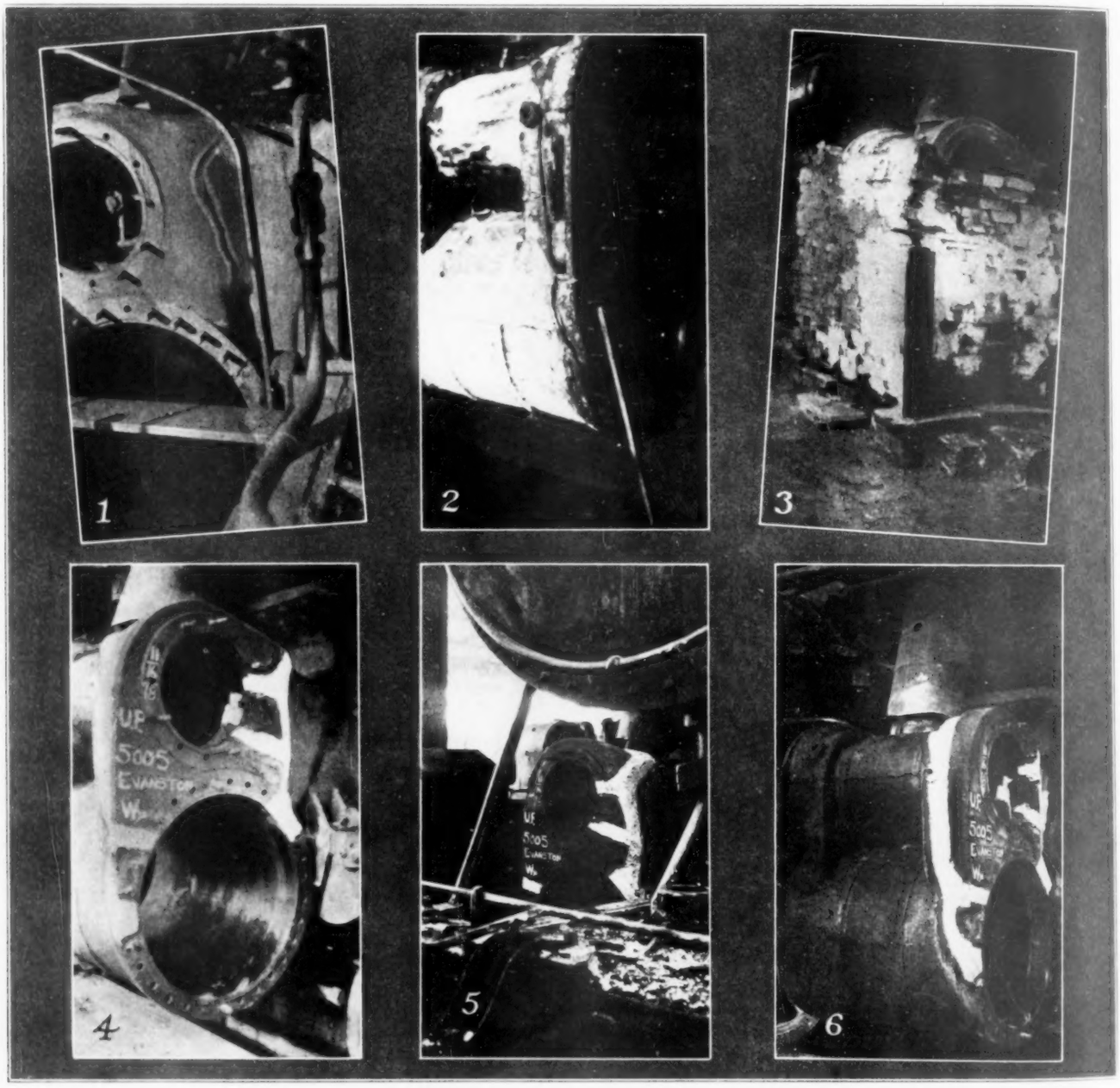
The cylinder shown was broken about Nov. 5, 1918, at Cheyenne, Wyo., round house, Union Pacific Ry. The break was caused by the cylinder bushing being loose in the cylinder and turning around so that the cylinder cock hole in the cylinder was plugged up. The engine is of the Santa Fe class with cylinder bore of 29½-in. As the engine was run out of the round house preparatory to taking the road with no outlet for the water that had accumulated in the cylinder the piston coming forward pushed out the whole front of the cylinder, including the valve chamber front.

The Union Pacific called their main offices for advice regarding what should be done with the cylinder, and the main office called upon the Oxweld people for aid.

The shops prepared the cylinder for welding by chipping the walls of the cylinder, making the opening for fusing the new metal in the crack as near 90 degrees as possible, also cutting to within ⅛-in. of the surface of the inside of the wall. There were three broken ribs in the side of the valve chamber that are used for reenforcing that part of the cylinder. To weld these bridges or ribs we cut a piece of the wall 12-in. to the right side of the valve chamber head joint and 8 in. high to give us an opportunity to weld down the inside of the walls.

After all places or cracks were cut out to the best advantage a furnace of fire brick, covering the whole cylinder, was built to preheat and take care of contraction and expansion. The fire was built and the cylinder was heated with a charcoal fire for four hours, to bring the whole cylinder to an even cherry red heat before beginning the weld. The welding was begun on the right side of the cylinder at the bottom of the crack, then opening where a piece was cut out for welding the bridges. From this point the bridges were welded, then the piece was put in place and welded in from there on to the top of the valve chamber. Two operators were used on this and needed rest. A man was left with the cylinder the rest of the night to keep an even fire and heat on the cylinder.

(Continued on Page 40.)



Welded Under Direction of I. H. Gill. Fig. 1, Before Welding. Fig. 2, Before Welding. Fig. 3, Preheating. Fig. 4, Ready for Machining. Fig. 5. Cylinder Welded. Fig. 6. Cylinder Welded.

Oxy-Acetylene U.S. Welding Apparatus

The "U. S." Welding Torch requires no introduction to the metal working world, as its high standard of efficiency in all classes of work within the range of the Oxy-Acetylene process has long been established. The mixing features entirely eliminate the troublesome flashback and insures a soft neutral flame which appeals strongly to the careful welder.

Agents wanted in every state.

UNITED STATES WELDING CO., Inc.

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Welders' Asbestos Gloves and Mittens

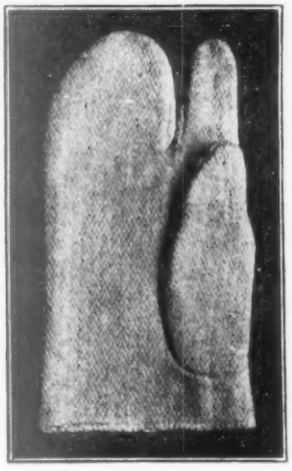
Wheeler
No. 403 Asbestos Glove

WHEELER PROTECTIVE WEARING APPAREL

Quality is the dominant feature of all Wheeler products.

Quality in material, manufacture, fit, comfort and durability all combine to make Wheeler Protective Wearing Apparel the very best protective apparel on the market.

The Wheeler line covers every item in asbestos, fireproofed duck and leather gloves, mittens, handleathers, leggings, spats, aprons, coats, pants, helmets, etc. Get in touch with us and let us tell you about them.



Wheeler
No. 462 Asbestos
1-Finger Mitten

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AUTOMOBILE WELDING

With the OXY-ACETYLENE FLAME By M. Keith Dunham

167 Pages Price $1.00 Fully Illustrated

This is the only complete book on the "Why" and "How" of Welding

Explains in a simple manner apparatus to be used, its care, and how to construct necessary shop equipment. Proceeds then to the actual welding of all automobile parts, in a manner understandable by everyone. Aluminum, cast iron, steel, copper, brass, bronze and malleable iron are fully treated, as well as a clear explanation of the proper manner to burn the carbon out of the combustion head. Automobile Owners, Garage and Service Stations, Blacksmiths and Machine Shops, as well as industries using the oxy-acetylene flame, will find this book of the utmost value, since the perplexing problems arising when metal is heated to a melting point are fully explained and the proper methods to overcome them shown.

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Sent to any address postpaid on receipt of $1.00 THE WELDING ENGINEER 608 So. Dearborn St. CHICAGO, ILLINOIS

How Can I Tell An Oxydizing Flame?

It would surprise you to know how many simple questions we are asked every month. Most of them are answered by Dunham's "Automobile Welding." In fact it answers many a question put up to me every month. It's a book every welder should have. The price of the book is $1.00 postpaid. Send me $5.00 today and I'll send you The Welding Engineer f or 3 years ($6.00) and the book ($1.00).

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This page is intended to be a directory of America's best shops. The cost of advertising is low. Write for details.

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Reg. U. S. Pat. Office.

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The American Welding Society.

WE have with us a new association which is to be known as The American Welding Society. If properly managed, and we believe the new association is in safe hands, much good should result. In fact, an organization of some kind, to champion the cause of welding, has been badly needed. The American Welding Society is to deal with all systems of welding and it is expected that the advocates of the several systems of welding will lend their efforts to the common cause.

When we went to war we were hopelessly unprepared—from a welding standpoint. We took advice, from a National standpoint, from every Tom, Dick and Harry. The result was just about what could be expected. At the end of the war we were doing better, but not so well as we would have done if we had been able to avail ourselves of the advice and assistance of an established Society, composed of all welding interests.

A great deal of harm is done the cause of welding by incompetent welders. We have no way of classifying them, but simply take their word for their ability—until they spoil a job. The result is that a great many people have lost faith in the art. In fact, at least three states prohibit pressure welding.

In England before you are recognized as a welder, it is necessary to present yourself for an examination as to your proficiency. You are then issued a Certificate of Proficiency, which officially fixes your status in the welding trade.

This is a work the new American Welding Society can well undertake. Geographical conditions make our task harder, but the work is worth while. We can afford to go to some expense to put the stamp of approval on competent welders.

Engineering Associations in many fields are interested in welding. The American Welding Society ought to be the answer. Their Committees ought to work out all of the problems and present all of the solutions necessary. All engineering and mechanical societies should be taught to depend upon us for reliable and timely information.

The owner and Editor of The Welding Engineer recommends that his welder friends back up this new association. It's bound to be a power for good—a help to welders. Plain welders are entitled to Class D memberships, which costs $5.00 (see March issue). The Secretary is Howard C. Forbes, American Welding Society, 33 West 39th Street, New York, New York.

SAFETY RULES FOR OXY-ACETYLENE WELDING.

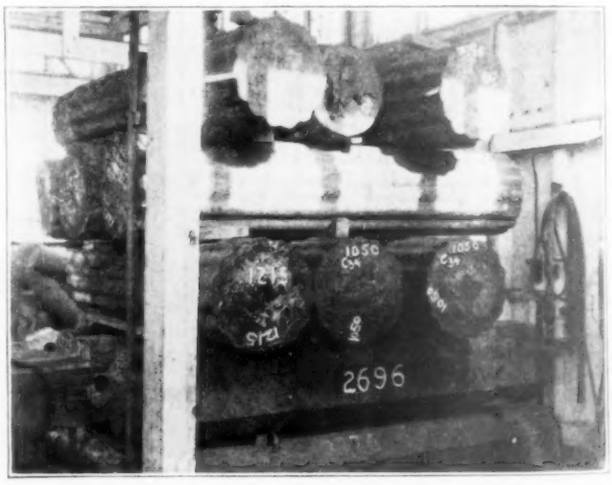
The following rules have been adopted by the Western Pennsylvania Division of the National Safety Council, and may well be observed by all who are engaged in oxy-acetylene welding or cutting operations, and the transportation or care of oxygen and hydrogen tanks.

Equipment.

1. All pressure tanks should be fitted with safety relief devices, and tanks not so equipped should not be used.

Burdett Plant at Seattle, Wash.

2. The equipment should include a high-pressure gage to indicate the pressure on the tank, a reducing valve, and a low-pressure gage to indicate the pressure on the torch. These should be assembled as one unit and so arranged that they need not be separated when they are attached to, or detached from, the tank. The two gages should have different sized openings; one should have a right-hand thread and the other a left-hand thread so that they cannot be interchanged. There should be one of these units for the oxygen tank and one for the acetylene tank.



Steel Billets to be Made Into Shafts for Large Ships, Cut to Length with Oxy-Hydrogen in Plant of Pacific Eng. and Construction Co., Seattle.

3. All pressure regulators should be equipped with a safety relief valve which will relieve the pressure from the diaphragm and low-pressure gage in case the high-pressure valve should develop a leak.

4. Wire-wrapped hose should not be used.

5. The oxygen and acetylene hose should be of different color or the couplings should be stamped for identification purposes, so as to avoid interchanging the hose.

6. The torches should be of a type which will not back fire.

Rules for Operation.

1. Under no condition should acetylene be used where the

(Continued to Page 40.)

PRACTICAL WELDERS

WANT TO KNOW

The Cost of Operation

OF

The Mephisto A. C. Welder

If your rate is 3c per k. w. h. your cost on average work would be under 15c per hour.

Compare this with your oxy-acetylene costs.

You can't disregard a saving of this magnitude.

A portable machine with welding current from 40 to 150 amps., with a tap for intermittent cutting. No regulating apparatus or moving parts, with efficiency of over 90%.

SEND FOR BOOKLET 600

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42 BROADWAY N. Y. CITY

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(Continued from Page 34.

The next morning the welding was continued across the top of the valve chamber, from the right side to the left side of the valve chamber and part way down the left side. As the operators required relief a man was left overnight with the same instructions as the previous night. The next morning an additional operator was on the job and the welding was finished that day.

When all welding was finished the cylinder was given enough fuel to bring all parts to an even heat and all cracks in the furnace were sealed up with fire clay to make an air tight furnace for annealing the whole job. Every possible crack was plugged to prevent draft and the fire was left to burn out slowly. The cylinder was left in the furnace until cold, then all remains of the preparations for welding were removed. The cylinder was calipered and did not show out of round more than 1-16 inch. The valve chamber was calipered and did not show out of round.

The cylinder was machined for all bearings and cylinder heads then a test of cold water was applied of 250 lbs. There was not a sign of a leak at any part of the weld. This was welded in November and has been giving good service every day between Evanston and Ogden.

The total welding cost of preparing and welding complete would be under $400, according to figures obtained, beside giving the engine back for service at least three weeks before they could put on a new cylinder, and this was during war times when an engine was needed the most. Of course the cost of the operators was not considered for they were Oxweld Instructors sent out for the work, under service contract.

The instructors who did the work were L. H. Gill and C. E. Allen, on the main or first part of the welding, then John Fitzgibbons arrived to help finish on the last day.

Total welding hours 38, total welding in ft., 38. Thickness of metal, from ¾ in. to 4 in.

SAFETY RULES FOR OXY-ACETYLENE WELDING.

(Continued from Page 38.)

pressure is greater than fifteen pounds per square inch.

2. Special care should be given to the storage of oxygen and acetylene tanks. Acetylene is classed as an explosive and only a limited number of containers should be stored in any one place. Oxygen tanks should be stored in a separate place from acteylene tanks.

3. Oxygen and acetylene tanks should not be allowed to remain near stoves, furnaces, steam heaters or other sources of heat, and should not be exposed unnecessarily to the direct rays of the sun, as an increase in the temperature of the gas will cause a corresponding increase in the pressure within the tank. Any excess of heat may also soften the fusible safety disk with which the tank is provided, causing it to blow out and permitting the gas to escape.

4. Oxygen tanks should never be handled on the same platform with oil or grease which might find their way into the valves on the tanks.

5. Oxygen and acetylene tanks should never be dropped nor handled roughly and should never be stood on end unless fastened so as to prevent them from falling over.

6. Tanks should not be handled by crane, either magnetic or mechanical.

7. All empty tanks should be marked plainly with the word "empty" and returned promptly to the store room.

8. An open flame should never be used for the purpose of discovering leaks in acetylene tanks. Leaks can generally be detected by the odor of the acetylene gas, and their location can be determined by applying soapy water to the surface of the tank and watching for the soapy bubbles formed by the escaping gas.

9. No repairs to oxygen or acteylene tanks or equipment should be made or attempted. All defects should be reported promptly to the foreman, and by him to the manufacturer.

10. Leaking acetylene tanks should not be used, but should be placed in the open air and all open lights kept away from them. All leaking acetylene tanks should be reported promptly to the foreman and immediately returned to the manufacturer.

11. All open flames should be kept away from any place where there is any possibility of acetylene escaping.

12. Care should be taken to protect the discharge valves of tanks from being bumped, as a jar may damage the valve and cause it to leak.

13. Grease in contact with oxygen under pressure may cause spontaneous ignition. Great care should be taken not to handle threads or valves with oily hands or gloves, and gages should not be tested with oil or any other hazardous carbon. If a lubricant must be used, the purest glycerine is permissible.

14. Gages, apparatus and torches requiring repairs should be sent to the manufacturer, and local repairs should not be attempted. Valve seats should never be replaced except by the manufacturer.

15. The use and operation of the pressure regulator or reducing valve on oxygen or acetylene tanks should be as follows:

a. Open the discharge valve on the tank slightly for a moment and then close it. This is to blow out of the valve any dust or dirt that might otherwise enter the regulator.

b By means of the stud or nut connection on the regulator, connect the regulator to the discharge opening of the tank.

c. Release the pressure adjusting screw of the regulator to its limit.

d. Open the needle valve slightly if there is one.

e. Open the discharge valve on the tank gradually to its full width.

f. Open the needle valve to its maximum if there is one.

g. Adjust the pressure regulating screw until the desired pressure is shown on the low-pressure gage.

16. The discharge valves on the tanks should be opened slowly, and care should be taken to avoid straining or damaging them by the use of a hammar or the wrong kind of wrench. A special wrench should be made for use in opening these valevs in case they stick.

17. When the operation of the cutting or welding torch is stopped for a short time, the needle valve on the regulator should be closed, or the pressure-adjusting screw should be released to keep the pressure off the hose. The torches should be opened momentarily to let the pressure out of the hose lines.

18. All tanks should be inspected at the close of the day's work.

19. Proper precautions should be taken to protect the hose from flying sparks.

20. All hose should be examined periodically at least once every week. This should be done by cutting the hose off at the end of the connection and examining it. In addition, after a few months' use, the hose should be cut off about two inches back of the connection and examined for defects. A defective hose should never be used.

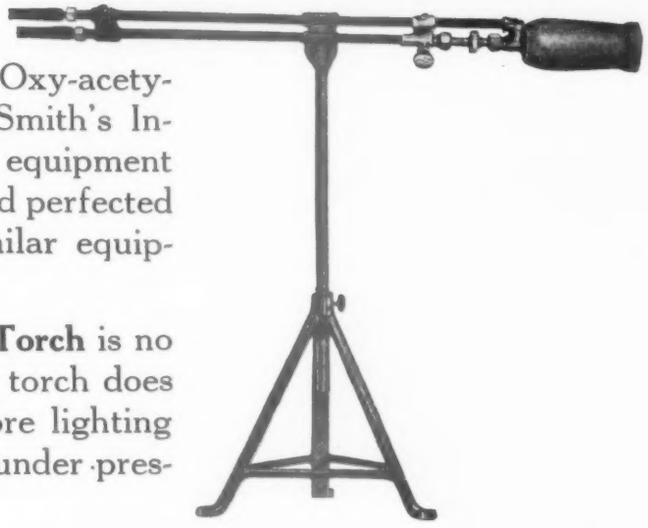
21. Special care should be taken to avoid the interchange of oxygen and acetylene hose or piping, as this might result in a mixture of these gases that would be highly explosive. The practice of using right- and left-hand threads is recommended.

22. White lead, grease or other similar substances should never be used for making tight joints. All joints and leaks in equipment should be made tight by soldering or brazing.

23. The oxygen and acetylene valves at the base of the torch should be tested daily for leaks.

24. Where hydrogen or other gas is used instead of acetylene, the same precautions should be observed as for acetylene.

SMITH'S KEROSENE PRE-HEATING TORCH



The announcement of new Oxy-acetylene Welding Equipment by Smith's Inventions, Inc. means that that equipment has been experimented with and perfected beyond that of any other similar equipment in the market.

Our Kerosene Pre-Heating Torch is no exception to this policy. This torch does not have to be heated up before lighting nor must the kerosene be fed under pressure.

An air line carrying about 40 lbs. air pressure feeds kerosene by vacuum system. The kerosene tube is simply dropped into a kerosene barrel or can. A valve opens or closes the kerosene tube. The torch works equally well with gasoline or crude oil.

The Torch can be lighted instantly, simply with a match. The torch flame may be regulated to vary from six inches to four feet.

The nozzle of the torch may be screwed off, and when removed the torch makes an excellent kerosene spray for cleaning motors, transmission cases, differentials, etc. Also an elbow casting may be screwed onto the nozzle, thus turning the flame at a right angle.

Smith's Automatic Acetylene Generator

—is the most economical method of producing acetylene gas. It not only produces gas from one-third to one-half the cost of acetylene in drums, but it does away with the inconvenience and the serious delays that drums cause. It supplies gas at a range of from three to twelve pounds pressure. Is easily adjusted to different speeds, may be moved on a small truck about the shop. It is a valuable investment for any welding shop.

Write for catalogue and full information.

SMITH'S INVENTIONS, Inc.

Manufacturers of Pistol Grip, Welding and Cutting Torches, Generators, Regulators, Welding and Cutting Tips, and other Oxy-acetylene Equipment.

Department No. 1. **MINNEAPOLIS, MINN.**

25. A fire extinguisher should be carried as regular equipment to be used in case of fire.

26. Men using welding apparatus should wear suitable welding goggles for eye protection, having frames that are non-conductors of heat (not celluloid), side shields to protect against hot particles of metal, and lenses of proper color.

27. Operator's clothing should be fireproof.

28. If valves become frozen, they should be thawed by hot water, not by flame or hot metal rod.

29. Home-made generators should never be used, as they are unsafe. Only generators permitted by the Board of Underwriters should be used.

30. Where acetylene is used from generators or is piped through the plant, an approved water seal should be interposed between the generator and the piping system, and individual water seals should be placed at each blow pipe. Water seals should be inspected daily without fail.

31. Portable generators should not be used inside the building.

32. Safety devices on tanks, generators or apparatus should not be removed or tampered with.

33. In welding brass or bronze, injurious fumes may be given off, making it desirable to wear a respirator.

34. Smoking while on duty should be prohibited.

35. Electric lights in a generator house should be enclosed in vapor-tight globes protected by the regulator guard.

36. Snap switches should be placed outside of the generator house in a suitable place, provided the house is isolated.

37. Piping which is used to carry acetylene or hydrogen should be painted a distinctive color.

38. The manufacturers should provide couplings for the hose which cannot be mistaken and put on the wrong hose. If the couplings could be made with proper connections, it would be impossible to make any mistakes.

39. In storage houses where hydrogen or acetylene tanks are stored, the wiring should conform to the same rules as for the generator house, so that an explosion could not be caused by defective wiring or a break in the bulb.

40. The valves on the piping should contain neither copper, brass nor bronze.

41. In opening the outlet valve of a full tank, do not remove the regulator.

42. The operator should not stand in front of the gages when opening the discharge valves on the tank. If the pressure goes off suddenly, it may possibly destroy the gage, and the glass and parts will be blown out at the front.

43. A label should be placed on every tank of oxygen, stating that it should be kept away from grease.

MICHAELS & MOURRE, INC.

We believe it will interest our readers to learn of the organization of a concern, whose efforts will be devoted toward the development of the welding industry, along manufacturing and jobbing repair lines. Mr. Auguste Mourre, the vice-president, is a practical welder and machinist of long experience and has been connected with the Bournonville Welding Co., of New York, as shop superintendent for about seven years. Mr. Charles Michaels has been engaged in this business for about ten years in different capacities, and has also been formerly connected with the Bournonville Welding Co.

They have five thousand square feet of space in the building they occupy, and are equipped with every device necessary to this business, including a machine shop with lathes, drill presses, grinders, millers, etc.

BOOK ON MALLEABLE IRON.

An authentic treatise on "malleable iron" has been written and published.

It is entitled "Malleable Iron" and is issued gratuitously by The American Malleable Castings Association, headquarters, Cleveland, Ohio.

Although phenomenal progress has been made in this particular industry during the last few years, little or no progress has been made in keeping the public informed regarding such activities.

In fact there is but one book on the market today treating on malleable iron and it is so many, many years out of date that it is of little value.

The latest booklet—although but a forerunner for a very comprehensive volume to be issued later by the Association is filled with most valuable data.

It is divided into three parts:

Part I.

What is Malleable Iron?

Part II.

The American Malleable Castings Association.

Part III.

The Uses of the Malleable Iron Casting.
Can Heavy Sections of Malleable Iron Be Completely Annealed?
The Skin of a Malleable Iron Casting.
Malleable Iron Castings Resist Rust.

A copy of this book will be sent to anyone mentioning this paper if they address the Association at Cleveland, Ohio.

TENSION WELDING IN CANADA.

In the United States, in certain localities, it is against the law to do tension welding. In response to an inquiry directed to the L'Air Liquide Society we have the following statement:

"If you mean "welding" of parts or patches subjected to a stretching strain such as is most frequently the case in the welding of patches on boilers or other pressure vessels, we do not know of any very definite laws or regulations applying in this country. The Canadian authorities generally govern themselves on the American regulations, but we know that in certain cases they have not raised any objection to the repairing of Marine boilers by the oxy-acetylene process, even when it involved the welding of patches that would have to stand a high tension strain, because they personally knew the operators that would have to perform the work, and were satisfied with their ability to do it satisfactorily.

"We are confident that as soon as the average welder in this country is fully conversant with the main problems encountered in the repairing of boilers, the authorities will feel more inclined to accept oxy-acetylene welding as a general mode of repair, even of construction of boilers and other pressure vessels of which the joints of the compotent parts are subjected to tension strains."

It is also against the law, by order of the Interstate Commerce Commission, to weld locomotive side rods, by any method. We understand, however, that Algona Central & Hudson Bay Ry Co. have welded side rods with the utmost satisfaction.

WELDING IN INDIA.

American welders, particularly manufacturers of all sorts of welding apparatus and supplies, please note. The Autogenous Welding & Repair Works, Fergusson Road, Lower Parel, Bombay, India, request catalogs and information relating to American welding apparatus. This is the leading welding concern of India and American manufacturers are urged to send their literature.

The Green Drum

"MORE GAS PER POUND"

CANADIAN CARBIDE

CARBIDE SIZES		PACKED IN
Medium	3½ x 2	1000 lb.
Small	2 x ½	100 lb. and
Nut	1¼ x ⅜	25 lb. drums!
Pea	¼ x ½	10 lb. - 5 lb. - 2 lb.
Miners Special	⅝ x ⅝	1 lb. tins

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SEND for BOOKLET WITH THIS COVER

Main Plant of
Canada Carbide Co.

WELDING IN OKLAHOMA.

The Empire Companies of Bartlesville, Oklahoma, one of the largest oil and gas companies in the country, recently moved in to their new home, the Masonic Building, and held open house on March 21st for the citizens of Bartlesville and their many friends from all parts of the country. A special car was chartered from Kansas City to Bartlesville by Mr. Ralph Morrison, local manager of the Empire Company of Kansas City. A party of Kansas City's leading business men made the trip.

The opening of the Empire's offices was a big success. Approximately 2,500 visitors took advantage to inspect the new offices, which are wonderfully furnished. Hundreds of beautiful bouquets of flowers added to the attraction.

One of the main events was the moving picture show, showing the Empire's numerous oil and gas developments. Another was a miniature oil rig in operation.

The welding and cutting demonstration which was held in the gas pipe line department's office proved to be a big attraction. The welding and cutting of pipe showed all the different connections which are used in pipe line work. Imperial oxy-acetylene welding and cutting equipments used in this demonstration were furnished by the Oxygen Gas Company of Kansas City, Missouri. Mr. C. R. Brock, superintendent and Mr. John Fink, assistant superintendent of the Empire Companies were in charge, asisted by Mr. J. R. Foran, president, and Mr. E. N. Stevens, welding engineer, of the Oxygen Gas Company, of Kansas City, Missouri.

ELECTRIC HEATING FURNACE.

An electric tool-tempering furnace, which uses the barium-chloride and salt principle, is proving highly successful in the South Philadelphia works of the Westinghouse Electric & Mfg. Co. The chief advantages of this type of furnace over those using gas, coke, oil or wood, are constancy and ease of control of heat, cleanliness, equal heating of each atom of the specific part of the tool to be tempered, low cost of operation, and excellence of the finished work.

WELDING CRANK CASES.

Editor: About a month ago at a meeting of the Northwest Welders' Association a member described a certain interesting operation on an aluminum crank case. The following is a description of the kink:

"In welding an aluminum crank case it sometimes happens that the side on which the welding operation is done, especially if a large section is filled in, warps slightly, shortening up the side on which the weld is made. This naturally throws the main bearings out of line, and the usual method is to scrape the bearings sufficient to make the crank case usable, or else to scrape the piece.

"It would be difficult to stretch the welded side of the case sufficiently to bring the bearings back into line but it is not a hard matter to shrink the opposite side of the case if the following method be used. First, place a long, rigid clamp on the side to be shrunk and set it up tightly, providing large bearings under the clamp at both ends by means of small, iron plates. Now with the aid of the welding torch or a preheating torch heat the side of the case that is clamped. This naturally tends to expand the metal and as the clamp prevents this expansion it will close up. By this means the bearings may be brought into line again. If the case is otherwise warped, place a strain on it in the direction it is desired to move it and heat. Bearing in mind that the temperature at which aluminum is most malleable is between 400° and 600° F. and that above 600° F. it rapidly loses its strength, it is well to apply the heat gently. Above 600° aluminum becomes brittle and will easily break or pulverize."

Note: The long side of the case might be shortened as suggested, but the bolt holes would be pulled out of line, and no doubt the case would contain internal strains. A better way would be to saw the short side, allow the case to return to its normal position, and weld where sawed.—Editor.

"A steel casting manufacturer does not pour his molds from a number of small ladles, but uses one large enough to pour the entire casting at one time. He also keeps the metal fluid so that dirt and impurities can get to the risers, producing a clean casting. Making a weld in steel is the same as making a steel casting. Following the analogy, the more metal that can be kept in a molten condition at a time in a weld, the cleaner it will be. Adding small quantities tends to produce laps and cold-shuts and to include impurities in the weld. A clean weld is the foundation of successful welding; therefore, the addition of small quantities of wire at a time should be avoided."

SCHOOL OF ELECTRIC ARC WELDING.

When rapid production became a pressing necessity, the Emergency Fleet Corporation established several schools for teaching men to operate the electric arc welder.

As is well known, electric welding came into prominent use in connection with the repair of the German liners and in the manufacture of new ships, where it was used for welding a great number of pieces which hitherto had been riveted at much higher cost and with much greater delay.

One of these welding schools was conducted under the supervision of the Lincoln Electric Co., of Cleveland, Ohio, and gave a complete course which enabled an entirely green man to learn the fundamentals of electric arc welding in a short time.

Now that the war is over, the Lincoln Electric Co. are continuing this same school and are putting its service at the disposal of any manufacturer who desires to teach his men the art of electric arc welding. Men can come to the school and be instructed in any phase of the operation by thoroughly competent instructors.

Section of Welding School at Plant of Lincoln Electric Co., Cleveland, Ohio.

A view of one section of the welding school showing the operating sets and switchboards for the operator's use is shown.

The lessons are of a strictly practical nature. The manual training idea has been followed out in the lessons on welding to a certain extent so that the operator may learn to weld by welding according to definite instructions.

It has been found by actual experience that if the operator is allowed to "play about" with the arc without any very definite object in view little was accomplished as far as the learning of the important fundamental principles are concerned.

After making up each sample weld the operator cuts it

Welds on Equal Pressure

The New MILBURN QUICK-WELD Torch

This newest development in welding apparatus makes it possible to use equal pressures of oxygen and acetylene on either light or heavy welding.

Over-supply of oxygen is eliminated, removing the danger of oxydizing the metal.

The QUICK-WELD will not flash-back. You can push its nose into the molten metal—you can burn its tip—it welds on just the same.

Being of simple and sturdy construction, it will withstand the roughest usage.

Send for folder No. 35 or let us send you a QUICK-WELD on apppoval.

For night work use MILBURN acetylene lights for construction, mining, railway or shop. Ask for booklet No. 25.

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in half and thus can criticise his own workmanship, and allow other and more experienced workmen to criticise it for him, so that he will know beyond doubt whether he is making a weld or not when he is operating an arc. It has been found that the method of intensive instruction described above produces better operators than the usual method adopted by corporations using arc welding—that is to set the green operators to work on simple, commercial jobs and allow him to gain his experience that way.

AMERICAN WELDING SOCIETY.

The first meeting of the American Welding Society was held on March 28, 1919, at the Engineering Societies Building, 33 West 39th Street, New York, and the constitution and by-laws were adopted as recommended by the Organization Committee.

The following officers were elected:

President—C. A. Adams, Cambridge, Mass.

Vice-president (for one year)—J. M. Morehead, New York.

Vice-president (for two years)—G. L. Brunner, Utica.

Directors for one year—W. M. Beard, New Yory; M. H. Roberts, New York; M. M. Smith, New York; L. D. Lovekin, Philadelphia; Alexander Churchward, New York; W. H. Patterson, Pittsburgh; Walter J. Jones, Philadelphia; C. A. McCune, New York.

Directors for two years—R. R. Browning, New York; A. C. Kinsey, Jersey City; Victor Mauck, Conshohocken; E. L. Hirt, South Bethlehem; J. F. Lincoln, Cleveland; H. M. Hobart, Schenectady; D. C. Alexander, New York; H. R. Swartley, Jr., Jersey City.

Part of Plant of Detroit Prest-O-Welding & Cutting Co. Gas Masks Were Welded Here. Fifty Girls Were Employed on this Work.

Directors for three years—L. H. Davis, New York; E. L. Mills, New York; D. B. Rushmore, Schenectady; James Burke, Erie; D. H. Wilson, Jr., New York; Hermann Lemp, Erie; C. J. Nyquist, Chicago; Alexander Jenkins, Baltimore.

It was voted that the charter should be held open for ten days and that those applying for membership in the American Welding Society before April 8th should be considered charter members.

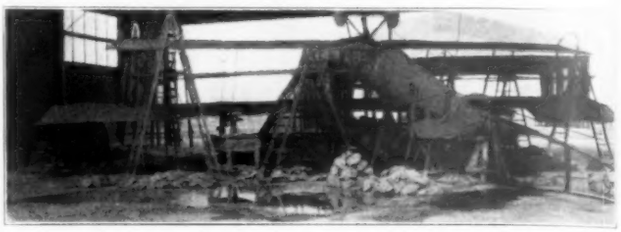
At a meeting of the directors in the afternoon, W. E. Symons was appointed treasurer and H. C. Forbes secretary.

About fifteen members of the trade attended a luncheon in Chicago last week, at which the question of holding a meeting of the Western members of the new American Welding Society was discussed. A meeting will be held shortly.

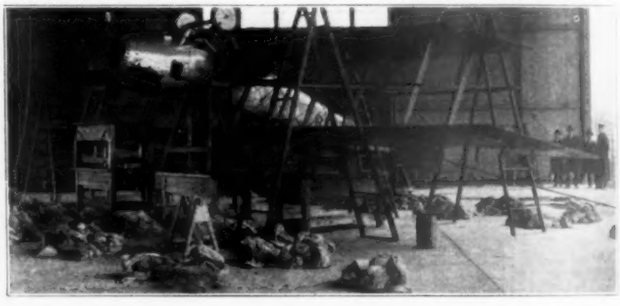
SAFETY PRECAUTIONS FOR HANDLING OXY-ACETYLENE APPARATUS.*

By E. Wanamaker,
Electrical Engineer, Rock Island Lines.

Unabsorbed acetylene, that is, in a gaseous state as generated, is highly explosive at a pressure of two atmospheres or more due to the chemical instability of the gas itself. Acetylene is more or less unstable and liable to sudden explosive decomposition under certain circumstances. Accidents sometimes occur when it is apparently impossible to guess what precipitated the decomposition which resulted in the explosion. Acetylene gas at ordinary atmospheric pressure and temperature does not fly apart spontaneously and explosively into its constituents, but does so when exposed to considerable pressure while in a wholly gaseous condition as previously stated.

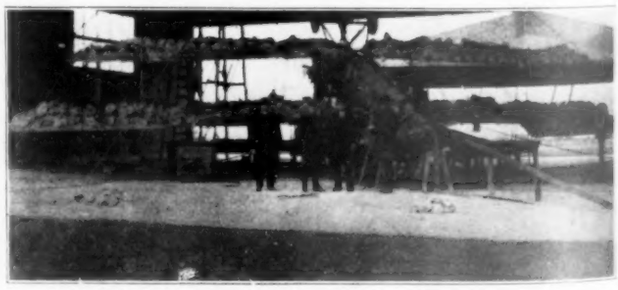


Steel Aeroplane Upside Down, Receiving Final Test.



Welding Construction Played an Important Part in Building Flying Machines.

It has been ascertained that acetone has the property of being able to absorb about 25 times its volume of acetylene for each atmosphere of pressure at 60 deg. F. When acetylene is dissolved in this way it ceases to be spontaneously explosive and may be stored with acetone at pressures up to 250 lb. with comparative safety. Persons not fully acquainted with the properties of acetylene gas should under no conditions be permitted to undertake the compression of it.



These Three Views Show Various Stages of Inspection of Aeroplane Welding.

Acetylene gas is comparatively non-poisonous when inhaled in highly diluted form in small quantities such as

*Abstract of a paper read before the Railway Fire Protection Association on December 4.

Electrolytic Oxygen

For cutting and welding operations it is of paramount importance to have oxygen of highest purity, free from inert elements.

Electrolytic Oxygen produced today is 99.5% pure or better and the remaining element is pure hydrogen, an active element which is consumed in the heating flame and in no way retards efficiency.

Tests carried out and reported by J. M. Morehead, late Chairman of the Oxygen Section of the War Industries Board, led him to the following conclusion, expressed before the New York Railroad Club:

> "In cutting it is quite essential that oxygen be pure and if any appreciable amount of nitrogen is present, this nitrogen expands with the heat and prevents the acetylene from entering the slot. This results in a wide kerf and unsatisfactory work, while at the same time the amount of oxygen necessary for any given work increases enormously."

M. Amadeo, the well-known technical director of the Union de la Soudure Autogene, Paris, as the result of a long series of cutting tests, reported to the International Acetylene Congress at Rome as follows:

> "The presence of nitrogen in the oxygen manifests itself by a considerable slowing up of the operation and the lessening of the penetrative power of the stream of oxygen.
>
> "The loss of speed of the cut for thicknesses from 10 to 30 mm. is proportionate to the amount of nitrogen contained.
>
> "Nitrogen magnifies the effect of scales and blow-holes and increases the changes in the metal which are made by the heating flame along the line of the cut—
>
> "Hydrogen in small quantities has no influence whatever upon the cutting operations."

For Economy and Efficiency use only electrolytic oxygen.

Purchase it at service stations from the following manufacturers:

CALIFORNIA
California Burdett Oxygen Co., Los Angeles.
California Burdett Oxygen Co., Oakland.

COLORADO
Burdett Oxygen Co., Denver.

ILLINOIS
National Oxygen Company, Chicago.
Acme Oxygen Company, Chicago.
Burdett Oxygen & Hydrogen Co., Chicago.
Swift & Company, Chicago.

INDIANA
Indiana Oxygen Company, Indianapolis.
Logansport Oxygen Company, Logansport.

IOWA
Bettendorf Oxygen Hydrogen Co., Bettendorf.

KENTUCKY
Kentucky Oxygen & Hydrogen Co., Louisville.

MICHIGAN
Michigan Ox-Hydric Company, Muskegon.
National Oxygen Company, Detroit.
Burdett Oxygen Co. of Detroit, Detroit.

MISSOURI
Oxygen Gas Company, Kansas City. (Two plants in Kansas City.)
St. Louis Oxygen Company, St. Louis.

MONTANA
Mountaineer Welders Supply Co., Butte.

NEBRASKA
Balbach Oxygen & Hydrogen Co., Omaha.

NEW YORK
Standard Oxygen Company, New York City.
International Oxygen Company, College Point, L. I.

NEW JERSEY
International Oxygen Company, Newark.

OHIO
Burdett Oxygen Co. of Cleveland, Cleveland.
Ohio Chemical & Mfg. Company, Cleveland.
Dayton Oxygen & Hydrogen Products Co., Dayton.
Ohio Electrolytic Oxygen Company, Cincinnati.

OKLAHOMA
Burdett Oxygen Co. of Oklahoma, Oklahoma City.

OREGON
Portland Oxygen & Hydrogen Co., Portland.

PENNSYLVANIA
International Oxygen Company, Verona.
Burdett Oxygen Co., Philadelphia. (Plants at Chester and Norristown, Pa.)
Burdett Oxygen & Hydrogen Company, Pittsburgh.

TENNESSEE
Burdett Oxygen Co., Chattanooga.

TEXAS
Burdett Oxygen Co. of Texas, Ft. Worth.

UTAH
Whitmore Oxygen Company, Salt Lake City.
Utah Burdett Oxygen Company, Salt Lake City.

WASHINGTON
Washington Burdett Oxygen Co., Seattle.

WISCONSIN
Universal Oxygen Company, Sheboygan.

Gas Products Association, Chicago, Illinois

801 MARQUETTE BLDG.

might escape from small leaks; the only poisonous effects that have been observed in connection with it were due to the presence of impurities in the gas, such as phosphoretted hydrogen. Therefore acetylene should always be secured as free as possible from phosphorous and other contaminating substances.

It has been found that one pound of carbide will generate 46 cu. ft. of acetylene gas, which if permitted to leak into a room six by six by five feet, will mix with the air in such a proportion as to make it an inflammable explosive that may be set off by a spark as well as by a hot iron or flame. For this reason it is always well when using an acetylene torch in a small enclosed space to see that a sufficient quantity of air is obtained to prevent accidents from such a cause. A little air blowing from an air hose will prevent any such accident as this even though considerable acetylene were leaking into the space.

Oxygen is manufactured directly as a chemical product or electrolytically from water. Oxygen itself as a gas is non-explosive. However, it is generally stored in metal containers at a very high pressure, generally about 1,800 lb. per sq. in. It is therefore apparent that an explosion may take place due to the failure of the container itself permitting the gas to rush out at an enormous velocity.

It has been found at times when oxygen was made electrolytically, that due to the crowding of the pressure or careless handling a small percentage of hydrogen was permitted to mix with the product. Certain proportions of this mixture are highly explosive and may be set off by heat or jar. It is therefore necessary that oxygen be pure.

The following instructions for handling oxy-acetylene gas are strongly recommended:

In handling acetylene gas in tanks under pressure it should be remembered that at no time should the tank be allowed to remain near stoves, furnaces, steam radiators or any other sources of heat nor should they be exposed unnecessarily to the direct rays of the sun. Care should also be used in handling acetylene gas containers to avoid heavy jars. It must be remembered that any steel drum is liable to mechanical injuries if not reasonably handled. Acetylene cylinders should always be stored in an upright position with the valve end up.

Leaking containers should never be used and should one be found, it should be set out in the open air as soon as possible away from all possibility of ignition of the gas or of the mixture of gas and air that surrounds the container.

Open flame lights should never be taken into confined spaces where there is any possibility of leakage of acetylene. In case it is found necessary to use an acetylene tank in a small enclosed space a little air should be blown into the space from an air hose in order to secure a good circulation of the atmosphere.

All acetylene containers should have fusible plugs.

Neither oxygen nor acetylene containers should ever be allowed to remain where they are exposed to sparks or flame.

Oxygen containers should not be dropped nor handled roughly in any way and should not be placed where they may be overturned by a collision with other objects or by reaction caused by the violent escape of their contents through the safety outlet with which containers should be provided.

The regulating devices, valves and other attachments on oxygen containers should never be lubricated with oil or grease. Whenever lubrication is required it should be secured by the use of pure graphite unmixed with either oil or grease. Furthermore the discharge valves of oxygen tanks should always be opened slowly and care should be taken to avoid twisting or straining them by the use of hammers or improper wrenches.

The hose and hose connections used between the gas manifolds or gas tanks and the welding torch must always be maintained free from leaks and all joints made mechanically tight and secure. The regulating valves and torches must be kept in a good state of mechanical repair to avoid leakage of the gases. No part of the equipment to which hose is attached should be used without securing the hose with the proper size hose clamp. Wire fastenings should not be used in any case.

In case of any trouble with the torch the gas should be immediately shut off at the tanks or pipe line station.

Where generating stations are used the instruction cards sent with the parts must be carefully followed and no leaks must be permitted on any of the pipe lines.

No man should be permitted to use the gas welding torch until properly instructed by a welding supervisor or some experienced welder and if he is not the regular operator permission of the foreman in charge should be obtained before the machines are used.

Safety gauges should be used on all regulators, that is, gauges having loose or vented backs, so that in case the pressure on the gauge builds up to a dangerous degree or builds up too rapidly, such as might cause a rupture of the Bourdon tube the force will spend itself without breaking the glass case, thereby causing possible injury to the operator.

Some shops use portable welding outfits, purchasing tanked gas and tanked oxygen. Other shops install acetylene generating outfits, also oxygen generating outfits, piping the gas throughout the shops having manifold outlets to which the hose from the welding torches are connected. Still other shops generate acetylene gas and purchase tanked oxygen, connecting it to a manifold which in turn is connected with a system of piping in much the same manner as the oxygen generating plant. Each generating plant that is installed is equipped with a complete set of instructions for intelligently operating the generator, the most important of which are: "Remember to keep all light or fire of any kind away from the plant and never permit the generator to remain more than five minutes unless the generating chamber is filled with water, even when it is not in use." If the instructions that we have given in this paper and the detailed instructions which are given out with the generators are carefully followed out and leaks of all kinds prevented in the distribution piping system of the installed plants, there will be practically no danger from fire.

SPOT WELDING RAILROAD TINWARE.

A LARGE proportion of the sheet metal work used on railroads is subjected to rough usage and for that reason it must be strong if it is to give satisfactory service. In order to secure the required strength, the joints in many cases must be riveted. Riveting is slow and therefore an expensive operation, especially when the rivets must be soldered to prevent leakage. The process of spot weldnig has been applied to the manufacturing of sheet metal ware during the past few years with great success. As the simplicity of the process and the great strength of the joints seemed to make it well adapted for railroad work, the Illinois Central about a year ago investigated the possible savings that could be effected and purchased an automatic welding machine.

It consists of a case containing the electrical mechanism with two arms extending from the front to which the electrodes are attached. The lower arm can be moved vertically by a screw engaging a crosshead at the front of the frame. The upper arm is stationary, but the electrode is mounted on the end of a bell crank operated through a horizontal rod from a cam in the body of the machine. This machine has a three speed transmsision driven by a 1½-hp. 220-volt A. C. motor. A hand wheel at the left of the upper electrode varies the speed to give one revolution in one, two or four seconds. On the cam shaft is a magnetic clutch operated by a pedal switch on a flexible cable. If the operator presses

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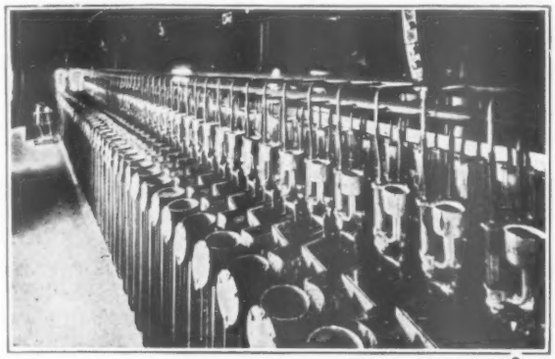

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shipped from our plant in complete units, and are installed under specific guarantees.

Levin cells are absolutely safe; there are no leaky joints, and no interruptions due to faulty design. The entire equipment is simply and economically operated.

Above all your Oxygen supply is assured as long as your water supply and electricity hold out.

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I H. LEVIN, Technical Director

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his foot on the switch once, the machine makes one weld, but if he holds his foot on the switch one weld will follow another at regular intervals, depending on the speed for which the machine is set.

The cam action is transmitted to the bell crank through a lever and then through a horizontal pressure rod. The lever has an adjustable fulcrum providing a lift of ¼ in to 1½ in. for the upper electrode. The pressure of the electrode on the work is changed by a hand wheel which varies the stress on the spring in the pressure rod to the bell crank. The electrodes are cooled by a continuous flow of water. The points have a Morse taper fit and are adjustable for various types of work.

The time during which the current flows is regulated by a hand wheel on the right side directly opposite the speed control. The time can be varied by small increments from zero to two seconds which makes it possible to weld from the thinnest stock up to ⅜ in. on this machine. The capacity is dependent on three factors, the amperage of the transformers, the current between the electrodes and the length of time the welding current flows, all of which are automatically controlled in the machine, after the original adjustment has been made. The machine when once set for the gage of stock involved is automatic in its action. The amperage, pressure and time are adjusted by a foreman or electrician thoroughly familiar with the work of electric spot welding, after which any operator capable of feeding the work can secure perfect welds. The automatic features of the machine are important in reducing the cost of labor and in eliminating the waste due to burining or imperfect welds resulting from poor judgment on the part of the operator.

The machine installed at Burnside has proved well adapted for work on railroad tinware. It welds bright tin and black sheet iron very readily. The parts must be flat so that a good contact will be made between the contact points and the surfaces must be free from rust. Galvanized sheets are more difficult to weld satisfactorily, but by using a slow speed and a comparatively low current with small contact points the zinc coatings can be pierced and a good junction secured. In making ventilator screens it has been found quite feasible to weld brass screens to the galvanized frame.

Table I—Savings Effected by Welding Kettle Ears.

Fastening Kettle Ears by Riveting	
Punching	0.68
Riveting	1.53
Soldering over rivets	.68
Total labor	$2.89
Rivets	.50
Solder	.30
Total labor and material	$3.79
Number of ears riveted	576
Fastening Kettle Ears by Welding	
Labor	$1.20
Number of ears welded	576

The savings effected by welding can best be illustrated by citing a few examples of typical jobs. In fastening kettle ears on buckets, the former method was to rivet them on, covering the heads with solder. Spot welding is much quicker and the cost is only 32 per cent of the cost of the riveting. A detailed statement of the cost of doing this work is given in Table I.

Table II—Welding Compared with Other Tin Shop Methods.

Name of part	Cost by former methods: Labor	Material	Total	Number made	Cost of welding	Number welded
Lamp chimney baskets	.....	.....	$10.56	100	$3.52	100
Sheet iron lamp shades	.....	.....	1.57	500	.85	500
Switch lamp lens bands	$20.00	$1.50	21.50	3,000	12.21	3,000
Stove pipe elbows	.....	.....	14.40	250	7.20	250
Ventilator screens	6.43	1.31	7.74	450	2.38	450
Split keys	52.00	10.00	62.00	20,000	30.32	20,000

Another typical operation to which spot welding has been applied is making the tops for water glass lamps. These were formerly soldered at a cost of $3.40 per thousand for labor and $.40 for material. The same quantity can be welded at a cost of $.85 for labor. On this job there is an

additional saving in the material from which the parts are made. When solder was used it was necessary to make the tops of tin, but sheet iron can now be used. The cost of other typical parts are tabulated in Table II.

The manufacture of flat split keys is one of the principal jobs handled on the spot welder. To expedite the work a special attachment has been devised. The framework holds a stationary disc, the edge of which is set between the welding points. Above this disc is a movable disc with recesses around the edge, of the same size and shape as the end of the cotter. Above each of the recesses is a spring which holds the parts when they are placed in the slots. At each evolution of the cam shaft the disc is advanced the distance between the slots by a ratchet operated by an electrically controlled valve, thus bringing the two pieces making up the key into position between the electrodes. A contact is then made and the parts are welded after which the ratchet advances them one notch further. The welded cotter then passes over an opening in the stationary disc where a finger on a rod attached to a lever on the upper arm of the machine strikes it, causing it to drop into the receptacle beneath. The parts can be welded as fast as the operator can feed them. As many as 5,000 cotters have been made in seven hours.

Another important job for which special attachments have been made is the welding of locomotive jackets. The large sheets are placed on rolling tables as shown in Fig. 3 and are simply lapped and welded together along the edge at intervals of about ¾ in. to 1 in. The description of some of the typical parts made by spot welding as given above will serve to show the adaptability of this machine. Further developments are to be expected and devices of this type will probably become important adjuncts to railroad tinshops.—Ry. Mechanical Engineer.

WELDING AS A PROCESS IN SHIP CONSTRUCTION.*

DURING the war, economy of time in the production of all that was needed to terminate hostilities successfully was of paramount importance. Economy in first cost and maintenance was relatively unimportant. If the production of a ship, an aeroplane, a tank or any implement of war could hasten the end by a single day it was more economical, in the long run, to place that implement on service today instead of tomorrow, even at a somewhat higher cost, for the shortening of the struggle by that single day meant a saving of many lives and millions of dollars. But besides being called upon to save time the engineer was forced to economize in labor and to use unskilled workmen. During the war gas welding and electric welding have been enormously developed as processes in the manufacture of munitions of all kinds. It goes without saying, therefore, that in these processes engineers found a means of saving time and labor.

Now that hostilities have ceased, economy in first cost and maintenance becomes once again of primary importance, economy of time and labor being of value in so far as it results in cheaper production. This is particularly true of shipbuilding. Every shipbuilder should now carefully review the various items of cost in the production of a ship, and while he may devote his energies to a reduction all round, he will, if he be wise, give greatest attention to a reduction in the cost of the most expensive of those items. Riveting is this most expensive item. It has been estimated that the labor cost of riveting is about 40 per cent of the total labor cost of building the structure of a steel cargo carrier, while the labor cost of shopwork on structural material is about 15 to 20 per cent. During the past few years considerable attention has been given to improvements in shopwork and it is unlikely that much economy can be effected in this direction. Can anything be done to lower the cost of riveting? The advocates of welding reply, "Yes, by a wide substitution of welding for riveting." This is a claim that should not be lightly placed on one side but carefully and critically examined by all shipbuilders. To offer some slight assistance in that examination this paper has been prepared.

Gas welding has been used in shipyards for many years, resulting in economy in the production of staple angles and similar smith work. It has found a wide field in the construction of light fittings, being more particularly of value for thin work than for heavy plating. As it may be considered that gas welding has now found its level as a shipbuilding process, this subject is not enlarged upon; the little that is said must not be taken as a measure of its importance.

Electric welding as a science and art has been dealt with at this meeting. As a process in shipbuilding much literature on the subject already exists, the most comprehensive papers known to the author being that by Mr. W. S. Abell, chief ship surveyor of Lloyd's Register, read before the British North East Coast Institution of Shipbuiders and Engineers at Newcastle in November, 1918, and that by Mr. H. Jasper Cox, read before the Society of Naval Architects and Marine Engineers at Philadelphia in the same month. The author makes no attempt, even if he were capable of doing so, of giving such detailed particulars of the subjects as can be found in these and other papers, but he does attempt to speak, as a shipbuilder to shipbuilders, plainly and impartially, without extravagant claims, and with some little knowledge of experience so far obtained, on the present position of the process and the policy which should be adopted, looking towards the future.

It is very well known that electric welding has been of great value on repair work, particularly during the war. Ships that would otherwise have been laid up for weeks while new castings were obtained, old plates removed and replaced by new, etc., etc., have ben rapidly repaired and returned to service. If the ship repairer finds a process of such value the shipbuilder should at least inquire whether it would not be of some value to him.

The Clasification Societies have sanctioned the use of electric welding for a considerable amount of work of little importance so far as structural strength is concerned. The Welding Committee of the Emergency Fleet Corporation has found by actual experience that a labor saving of at least 60 per cent results from the substitution of arc welding for riveting on these minor parts of a ship; and Mr. J. H. Anderton has estimated that a saving in time of 70 per cent was effected at Hog Island.

Lloyd's Register of Shipping is prepared to classify an electrically welded vessel, subject to the notations, "Experimental" and "Electrically Welded," and provided the builders conform to certain rules. This decision was reached after an extensive and exhaustive series of trials. Before any electric welding system can be employed on a vessel which Lloyd's will classify, specimens welded according to that system must satisfy tests which, at first sight, appear almost prohibitive in their severity, but an electrically welded ship is now under construction at Cammell Laird's, England, to be classified by Lloyd's, who have approved the employment of the Quasi-Arc Company's system in its construction. This is a small vessel about 150 feet long, with plating generally ⅜ to ½ inch in thickness.

Electric welding work carried out by the British Admiralty has been described in a paper read by the author before the Engineers' Club of Philadelphia, in July, 1918. Since that time valuable experience with this work on service has been obtained. The arc welded barge has been satisfactory. The cost of material, electric current and labor for this vessel was £301 ($1,463) as compared with £389 ($1,892) for the cost of riveting, caulking and drilling on a similar barge constructed at the same yard. The vessel was designed to be

*A paper read by S. V. Goodall, Constructor Commander, R. N., at the Seventh Midwinter Convention of the American Institute of Electrical Engineers, New York.

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rivetless as a demonstration of arc welding; it was found that greater economy would result if certain parts, such as beams to frames, floor plates to angles, etc., were riveted.

As the plating of this barge is thin and the stresses to which it is subjected are not comparable to those which a large seagoing ship is called upon to withstand, greater interest attaches to experience with other British ships in which arc welding has been employed by the Admiralty, particularly to those where the work has been comparatively heavy. It must be said at once that failures of welded joints have been reported, although the number of such failures has not been large considering the amount of work that has been done, the lack of experience, the dearth of skilled operators, and the radical change in method. The Admiralty authorities, however, consider it wise, pending further experience, to defer the adoption of electric welding for those parts of the structure subjected to high complex stresses unless the work can be so tested as to demonstrate exactly that such stresses can be safely carried.

Lap welding has been more satisfactory than butt welding and the latter has been, for the present, discarded for all important work where the plating is ⅜ inch or more in thickness. It is hoped that this situation will not last long, for it is in butt welding that the greatest gain from the use of this process may be expected, and lap joints necessitate a certain amount of overhead welding which is difficult and unreliable.

While the above briefly sums up the present position of electric welding as a process in shipbuilding it may be fairly asked why—if the Classification Societies permit the process on minor parts; if Lloyd's are prepared, subject to certain conditions to clasify an electrically welded ship; if the British Admiralty has employed the process to a considerable extent; if American railroads have used welding extensively on locomotives—why has not electric welding been adopted in American shipyards to a greater extent than it has been up to the present? There is no doubt that during the war, shipbuilders in the United States were too hard pressed to be able to give much time and thought to the development of an entirely new process in ship construction. This is one reason. Innate conservatism is another. But the real reason, in the author's opinion, is that shipbuilders know that, at present, welds are lacking in uniformity, and it is not yet possible to tell when the welded joint is good or bad. Hence they hang back and the author commends their wisdom. It is far better that the first ocean-going electrically welded ship should be on service three years hence with every joint sufficiently sound—universally accepted as a thorough success—than that it should be at the bottom of the sea tomorrow because, while 999 joints were sound, one went astray.

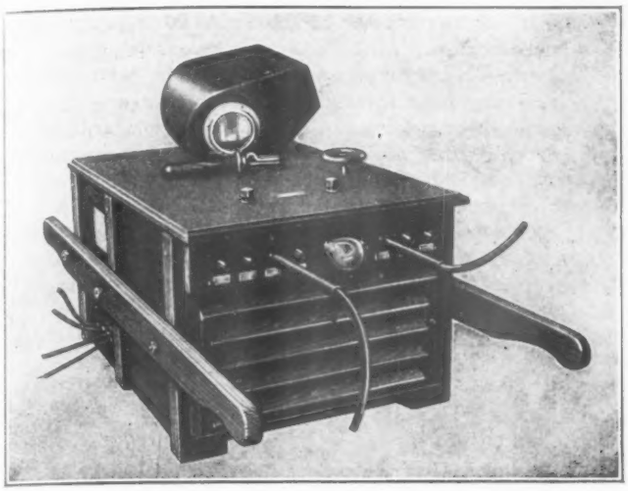
How can this certainty that every joint will be efficient be ensured? While the electrical engineer and the metallurgist can assist the shipbuilder to solve this problem, there is much that he himself can do.

In the first place he must realize the importance of employing only thoroughly skilled and experienced workmen and he should call in the manufacturers of electric welding apparatus to assist him. The latter, for their own protection and the welfare of the industry on which they rely, should see to it that no ship should be allowed to be built with some of the thoroughly rotten work done by absolutely unskilled welders that the author has seen in this country. It is strongly urged that steps should be taken at once to establish welding as a skilled trade and only certified men should be allowed to be employed. All the reports that have been seen on good and bad welds lay stress upon the fact that, in general, defects are mechanical and not an inherent feature of the process. Skilled men working under an experienced foreman would know, for example, that clean surfaces are necessary for good work, they would quickly learn what types of joint are made with ease, in what portions of a ship welding is cheap or where it is unreliable, and from their ranks should be drawn the draughtsmen who will design in detail the welded vessel of the future. The Electric Welding Committee of the Emergency Fleet Corporation has spent much time and thought on the attempt to discover a practical non-destructive method of testing welds. While such a method of testing would be very valuable, it is the author's opinion, that when only welders of proved skill are employed under experienced supervision, such tests would be no more necessary than a shear test on every rivet of a riveted ship; but, so long as such welders are not available the shipbuilder will look askance at a process that may be good generally but may have weak spots of which he is ignorant.

Secondly, after he has trained a reliable staff of welders on work of minor importance the shipbuilder must devote his attention to the best method of assembly of large parts, so that he may feel reasonably sure that every joint of the finished structure possesses the qualities which his welders can with certainty produce in test pieces. From the very outset it has been realized that this is a difficult problem which can be solved only by patient trial and experience. Present opinion at the British Admiralty is that the only satisfactory method is by the use of closing bolts as for riveted joints. In the case of the Richborough barge a certain amount of buckling resulted on the outboard edge of the garboard strakes after these plates had been welded to the keel plates, but this was removed when the bilge plates were put into position and bolted up. In the heavier work it may be that, buckling of plates being impossible, the internal stresses set up in welding were the causes of the failures that occurred. It is understood that this method is being adopted at Cammell Laird's but, again, the plating of this vessel is not very heavy and it is definitely known that this feature received most careful consideration from the very beginning. In the author's opinion this difficulty is by no means insuperable. Its existence should spur on the progressive shipbuilder, for when he has solved the problem, by that much will he be ahead of his competitors.

In the third place it appears to be the fact that shipbuilding steel in Great Britain is more adapted to welding than shipbuilding steel in this country, and the former is also more regular in its qualities. If shipbuilders are satisfied that such is the case and are also convinced that electric welding has a great future in ship construction, they should take concerted action to ensure that steel producers supply the material best suited to their purpose.

So far the author has urged a careful survey of the possibilities of welding as a substitute for riveting only on the ground that the latter is the most costly item of labor on structural work and it behooves the shipbuilder to reduce that cost. But there are other advantages incidental to welding that must not be overlooked. A sound arc-welded joint is necessarily watertight and once such a joint with known efficiency can be made with certainty caulking is eliminated and the work of water-testing made easier. It must be admitted that, so far, the advantages anticipated in this direction have not been fully realized, but that they will be realized is only a matter of time, and it has already been fully demonstrated that welded joints, being stiffer, stand up better under test and there is no breaking away of the caulk such as is something experienced with riveted connections under water pressure. Another advantage is a saving in steel due to the absence of rivet heads and the smaller width of laps and butt straps. Some advocates of welding claim that the labor of marking off, punching and assembling will be much reduced, more particulaurly by the adoption of spot-welding, but the author is bound to say that at present he is not a convert to the adoption of spot-



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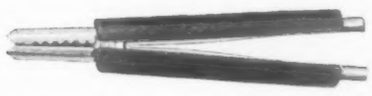

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welding for heavy ship work, it is his opinion that there are many difficulties ahead for those shipbuilders who attempt this form of welding and until those difficulties have been fairly and squarely met he hesitates to affirm that spot-welding will be found a valuable process in ship construction.

In conclusion, it is desired once again to place the subject before the shipbuilder in this light. The cost of ship construction must be reduced. A reduction in riveting is the most fruitful field for economy. Electric welding as a substitute has been tried to a limited extent and found successful. Classification Societies are prepared to accept the process, though at present the only vessels built or under construction are small. There are difficulties ahead but they do not appear insuperable. The best line of approach appears to be to build up a staff of thoroughly skilled welders, to gain experience by the adoption of welding on minor parts, to proceed cautiously in the extension of the process to more important members, not to expect a great saving in time and cost immediately, but to presevere, not necessarily towards the rivetless ship but towards a vessel in which the employment of both processes of riveting and welding is so adjusted that more riveting or more welding could only be done at greater cost.

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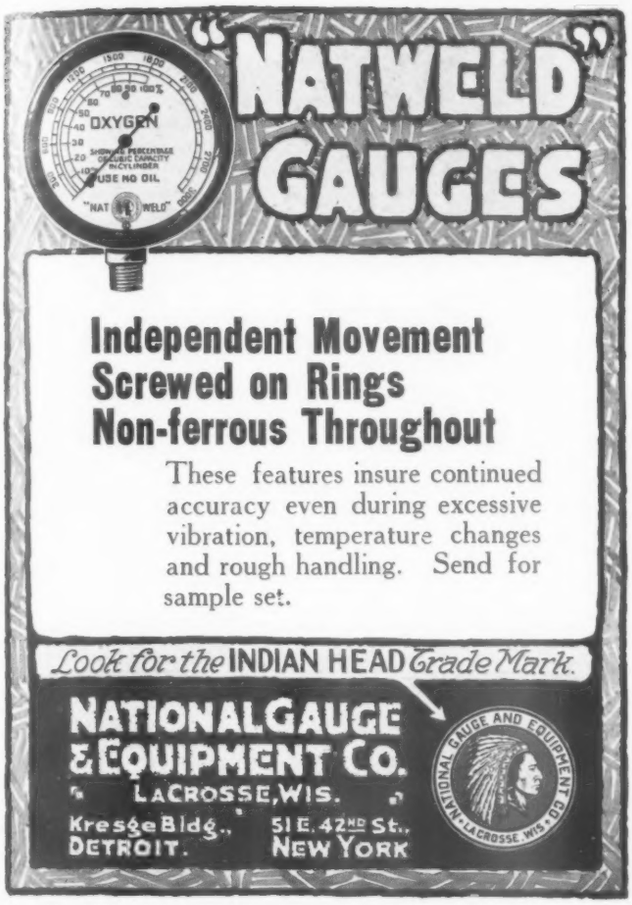
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Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912,

of The Welding Engineer, published monthly at Chicago, Ill., for April 1, 1919.

State of Illinois, County of Cook, ss.

Before me, a notary public in and for the State and county aforesaid, personally appeared L. B. Mackenzie, who, having been duly sworn according to law, deposes and says that he is the publisher of The Welding Engineer and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing edtor, and business managers are:
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Editor, L. B. Mackenzie, Chicago, Ill.
Managing Editor, L. B. Mackenzie, Chicago, Ill.
Business Manager, L. B. Mackenzie, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)
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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is —. (This information is required from daily publications only.)

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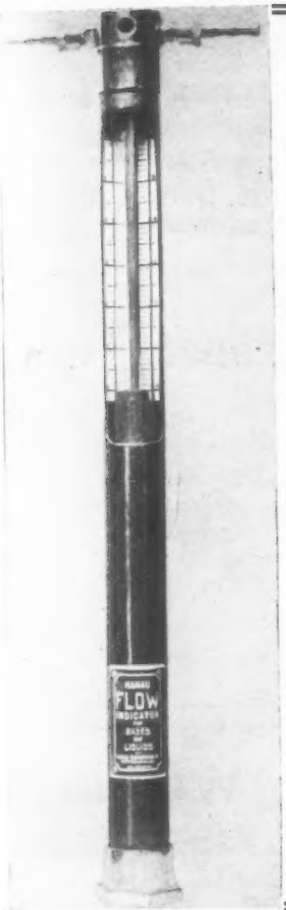

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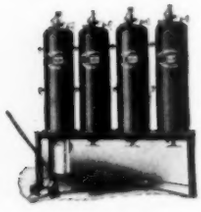

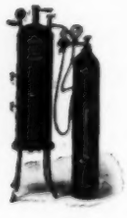

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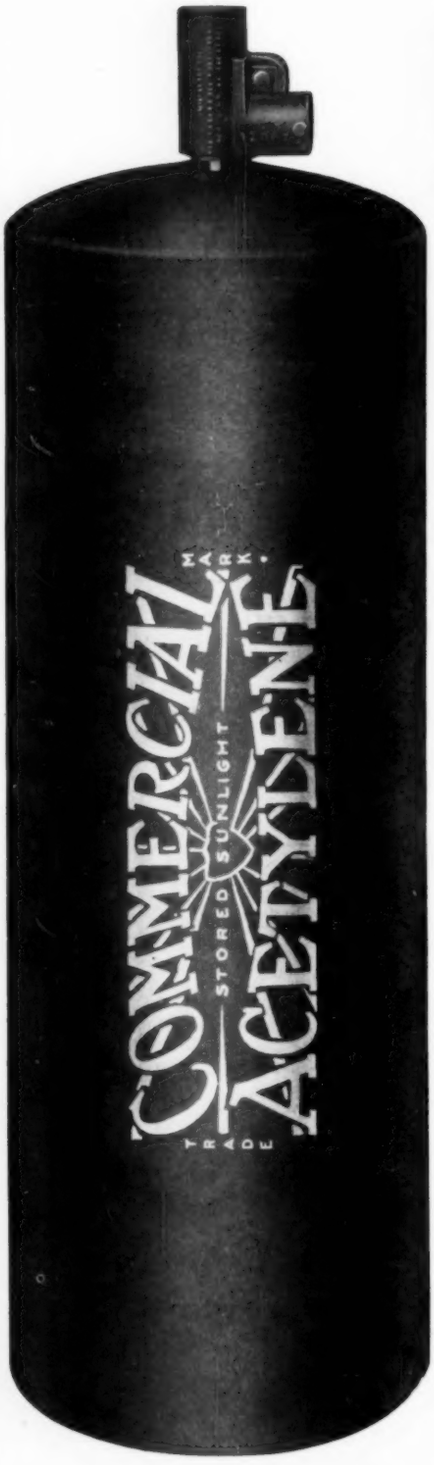

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